

# CALIFORNIA PATH 1997 ANNUAL REPORT



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## DIRECTOR'S INTRODUCTION

California PATH was founded eleven years ago in a remarkable joint decision by Caltrans and the University of California. The decision was based on the conviction that applications of information technologies could provide some solutions to California's steadily worsening transportation problems. That conviction is widely held today and underlies the Intelligent Transportation System (ITS) movement, but at the time few people could imagine the potential of ITS.

As they went about fashioning PATH's charter, its founders broke with established trends in transportation research in several other ways that contributed to PATH's success.

First, PATH is unique in bringing together electrical and mechanical engineers, transportation engineers and operations analysts, computer scientists and statisticians to work to improve the transportation system. As a result, more productivity-increasing technologies have been developed within PATH than any other transportation research center in the country. The technologies range from sensors and surveillance, signal processing and communications, vehicle and roadway based control methods, to software systems for use in a variety of traffic operations functions. A characteristic of PATH is the absence of any disciplinary orthodoxy: what counts is how well it works!

The second remarkable feature is that its sponsors recognize that it takes several years from research to development to testing and deployment, and they have been wise enough to hold PATH accountable for its efforts over the long run. That confidence has been well-placed. Judged by the quality of its work as well as its volume, PATH has provided high returns to its sponsors. This can be appreciated by anyone who peruses our website at [www.path.berkeley.edu](http://www.path.berkeley.edu).

Another indication of PATH's outstanding performance is that over the last five years, it has doubled in size and funding: a little less than half its support now comes from Caltrans, the rest is from the federal government and industry. Most significantly, the tradition of self-evaluation, peer review, and decentralized governance established within PATH has encouraged the growth and development of a creative, cooperative community that judges itself by high standards, a community committed to accepting and challenging ideas from all disciplines, and open to all research that is intellectually exciting and offers practical promise.

Many younger members of the PATH community have graduated from school or completed their post-doctorate terms and gone on to take up responsible positions around the world in academia, industry and government. The vision that led to PATH's founding eleven years ago is inspiring many others today.



A blue ink signature of Pravin Varaiya.

Professor Pravin Varaiya  
Director



## A WORD FROM CALTRANS

Caltrans is proud to be a founding member of the Partners for Advanced Transit and Highways program (PATH). Over the years, PATH has developed a high level of expertise in the area of Intelligent Transportation Systems research and has earned both national and international recognition as a leader in this field.

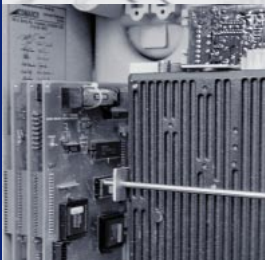
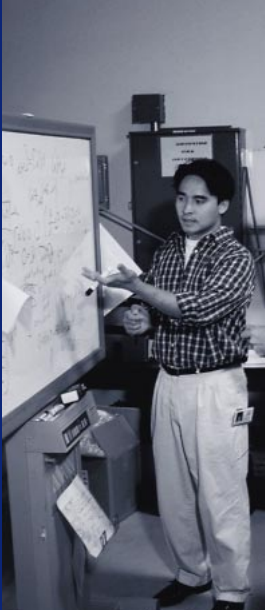
PATH has been very successful in forging partnerships between government, academia, and industry. In doing so, PATH has brought together the best available expertise to help meet the transportation challenges facing California as we move into the next century.

As Caltrans and its partners move towards deployment of Advanced Transportation Systems (ATS), PATH continues to play a vital role in helping find cost-effective solutions to mitigate congestion problems, enhance efficiency, and improve the performance of our transportation systems. The focus is on both short term and long term solutions that will substantially improve both the safety and capacity of California transportation systems.



A handwritten signature in blue ink that reads 'Hamed Benouar'.

Hamed Benouar, PE  
Management Liaison, Caltrans





# OVERVIEW OF CALIFORNIA PATH

The California Partners for Advanced Transit and Highways Program (PATH ) has been leading the way in ITS (Intelligent Transportation Systems) research since PATH's founding in 1986, before the term ITS or its predecessor IVHS (Intelligent Vehicle Highway Systems) had even been coined.

PATH's purpose is to develop the foundations for the widespread adoption of advanced technologies that will help improve the operation of California's surface transportation systems. In order to develop these foundations, PATH needs to identify impediments to progress, both technical and institutional, and develop strategies for overcoming those impediments. The PATH charter includes conducting leading-edge research, evaluating operational tests, developing public/private/academic partnerships, and educating both students and practitioners about ITS. However, it does not extend as far as deployment or operation of systems, which remain the responsibilities of the Caltrans district office operations and the relevant local agencies.

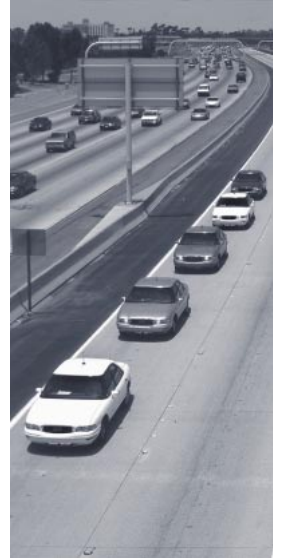
A key element of the PATH Program philosophy is the significant emphasis on areas that offer potentially dramatic improvements in the operations of the transportation system, relative to those that can make only incremental improvements. The growth of population and travel demand is so rapid in California that the effects of the incremental solutions are likely to be absorbed in this growth by the time they are implemented. At the same time that PATH addresses the relatively long-term, high-impact solutions, it also addresses the progressive steps that will be necessary to get to the long-term solutions.

The types of ITS research and development activities that occur under PATH auspices include:

- identification of problems and needs
- basic technological research on enabling technologies
- applied technology research and development
- system-level design and evaluation
- experimental verification of design predictions
- evaluations of existing technologies or equipment
- evaluations of costs and benefits
- technology assessments
- predictions of behavioral responses of users
- predictions of impacts of use of technologies
- evaluations of legal and institutional issues.

Caltrans has provided the seed funding for the core research of the PATH Program, based on the desire to promote the development of new technology and knowledge that can be used to improve the productivity, safety and environmental impacts of the operations of California's surface transportation systems.

The program is managed by the Institute of Transportation Studies of the University of California at Berkeley, which has established the PATH Program headquarters at the University's Richmond Field Station. Policy issues are addressed by the PATH Executive Committee in the University and the Caltrans-PATH Joint Management Team, which is comprised of program managers from both Caltrans





and the University. The day-to-day operations of the program are managed by the PATH Program Office staff.

PATH has about 50 full-time staff members, including program management and administration as well as a core group of research staff members. The majority of the PATH research is conducted on the campuses of the university partners, employing graduate students supervised by faculty members. A substantial body of research is also conducted by the full-time research staff at the PATH Program Office. These are supplemented by subcontracts to private companies as needed and by cooperative research agreements with a variety of organizations, including private companies as well as public institutions, both domestic and overseas. The more product-development oriented work of the private companies can serve to complement the more basic work of the academic researchers, so that each can concentrate on that to which it is best suited.

### **PATH Activities in National ITS Program**

PATH has had substantial funding from the Federal Department of Transportation (DOT). This has included support from the Federal Highway Administration (FHWA), Federal Transit Administration (FTA), and National Highway Traffic Safety Administration (NHTSA) on a variety of projects that predated the current DOT programs in ITS. The PATH participation in DOT ITS programs during the 1996-97 academic year includes:

- FHWA-Caltrans cooperative agreement for research on vehicle-follower longitudinal control;
- ITS System Architecture Program, subcontractor to the Rockwell team in Phase 2, focusing on evaluation of transportation impacts of the ITS architecture;
- PATH is one of the ten core participants in the National Automated Highway System Consortium (NAHSC), which began a seven-year effort to conduct the System Definition Phase of the AHS program in October 1994. PATH researchers are active in most of the tasks of the NAHSC work plan, and have the lead responsibility for developing AHS modeling and analysis tools. They are also working heavily on: 1) evaluation and development of enabling technologies for AHS, 2) development of an AHS demonstration (scheduled for August 1997), and 3) evaluation and selection of AHS operating concepts.
- Evaluation of California ITS Operational Tests:
  - TravInfo (Bay Area)
  - Smart Call Box (San Diego)
  - Adaptive Traffic Control (Anaheim)
  - Integrated Ramp/Signal Control (Irvine)
  - Mobile Surveillance (Orange County)
  - Wireless Spread Spectrum Communication (Los Angeles);
  - TransCal (Bay Area to Reno)
  - SmartCard (Ventura)
- Human Factors Design of Automated Highway Systems (AHS), subcontractor to Honeywell, providing technical review of work on definition of AHS operational scenarios and functions.



## State-Funded Core Program of ITS Research

The core of the PATH program is its collection of research projects funded by the Caltrans New Technology Program. Currently, there are about 95 such projects, which are selected on the basis of an annual Request for Proposal (RFP) and proposals submitted from throughout California. These involve the work of about 60 professors, representing 26 academic departments on thirteen different university campuses, supervising the research of over a hundred graduate students and post-doctoral researchers. The current projects are being conducted at: University of California at Berkeley, University of California at Davis, University of California at Irvine, University of California at Los Angeles, University of California at Riverside, University of California at Santa Barbara, University of Southern California, California Polytechnic State University at San Luis Obispo, San Diego State University, The Claremont Graduate School, University of Washington, Kyoto University, and Texas A&M.

PATH activities are subdivided into three broad categories:

- ATMIS - Advanced Transportation Management Information Systems (which includes the more traditional categories of ATMS, ATIS and APTS);
- AVCSS - Advanced Vehicle Control and Safety Systems (which includes Automated Highway Systems - AHS);
- Systems - the cross-cutting and institutional issues that apply to both ATMIS and AVCSS, as well as communications and system architecture.

The project descriptions that follow are organized in these three groupings.







## CURRENT RESEARCH PROJECTS

### ATMIS

(Advanced Transportation Management Information Systems)

#### ■ APTS (Advanced Public Transportation Systems)

##### Assistive Devices and Services for the Disabled

*Reginald Golledge, Geography, UC Santa Barbara*

Examines how auditory information (e.g. talking signs) and auditory travel guides (e.g. Personal Guidance System) can assist blind or vision impaired travelers to use public transit. In a pilot study, we first experiment with sign location (in terminals, on buses, on streets) and message content (natural vs. technical language). Pre- and post-testing of attitudes toward transit and transit use will be evaluated.

##### Efficient Transit Service Through the Application of Intelligent Transportation Systems (ITS)

*Randolph Hall, Industrial and Systems Engineering, University of Southern California*

Tracking and other ITS technologies have the potential to improve the productivity of transit systems in a variety of ways, including better schedule control, driver feedback, and improved data for route planning. This project is investigating the potential benefits and uses of ITS from the standpoint of efficiency. The project will focus on productivity efforts at the Orange County Transit Authority.

##### Evaluation of Orange County Transit/Traffic Management Integration and Traveler Information Project

*Randolph Hall, Industrial and Systems Engineering, University of Southern California*

The Orange County Transit Authority is conducting a test of bus tracking technology and the integration of traffic and transit information. A small fleet of buses in Anaheim and Santa Ana are being equipped with tracking equipment, to support bus dispatchers and collect probe information for traffic purposes. The project will evaluate the benefits of the technology, from institutional, user and system perspectives.

##### Functional and Interface Requirements for Advanced Public Transportation Systems

*Mark Hickman, Texas A&M University*

Analyzes the need for interface standards among information systems and APTS technologies at public transit agencies. This requires a detailed review of data, functional and interface requirements within a transit agency. Supplementing this review are case studies at several agencies to examine related technical and management issues.

##### Integrated Transit Services in Santa Clara Through Use of Automatic Vehicle Location (AVL)

*Ted Chira-Chavala, Institute of Transportation Studies, UC Berkeley*

The goal of this research is to evaluate benefits and costs of automatic vehicle location (AVL) applications to achieve multimodal and integrated transit services in Santa Clara. It will evaluate the improvements in four areas: 1) passenger information, 2) driver/dispatcher information, 3) vehicle schedule adherence, and 4) timing of transfer.

##### Intelligent Transportation Systems (ITS) Applications to Timed Transfer

*Randolph Hall, Industrial and Systems Engineering, University of Southern California*

A "timed transfer" exists when multiple bus routes are scheduled to arrive on or about the same time at a transit terminal, with the goal of enabling short waiting times. This project



investigates the application of ITS technologies to improve timed transfers, and to evaluate the technologies with simulations. The study is comparing alternative tracking technologies and control rules to see when and where investments are cost justified.

### **Rideshare and Personalized Public Transit: Potential and Realization**

*Jacob Tsao, PATH Headquarters*

Rideshare has actually been decreasing in most US metropolitan areas. This project studies two related subjects: the potential of rideshare as a function of spatial and temporal factors and the potential of the various concepts of personalized public transit for congestion reduction. After developing a framework for developing and evaluating intermodal transportation concepts and services for moving people, we will develop mathematical models to estimate the potential of ridesharing, with a goal of extending them to estimate the potential of the concept of personalized public transit.

### **Using Advanced Technologies to Increase Mobility and Accessibility of Special Needs**

*Paul Jovanis, Civil Engineering, UC Davis*

The objectives of this study are: 1) to define the characteristics, current travel behavior, and needs of travelers with special needs, in particular the elderly, and 2) to propose technological alternatives to increase their safety and mobility.

### **Ventura/Lompac Smart Card Demonstration Evaluation**

*Genevieve Giuliano, James E. Moore, II, Civil Engineering and Urban Planning and Development, University of Southern California; Ted Chira-Chavala, Institute of Transportation, UC Berkeley*  
Contactless Smart Cards are being evaluated as a mechanism for integrating transit services in a field operation test involving nine transit operators. The test includes electronic fare collection, automatic passenger counters, automatic data uploads and downloads to and from buses, and a geo-positioning system. Technical performance, user acceptance, institutional issues, transit agency impacts, and cost-effectiveness are evaluated.



## **■ ATIS (Advanced Traveler Information Systems)**

### **• General**

#### **Daily Activity and Multimodal Travel Planner**

*Ryuichi Kitamura, Kyoto University, Japan, and UC Davis; Paul Jovanis, Civil Engineering, UC Davis; Etak, Inc.*

A Travel Itinerary Planner will generate a day's itinerary based on input such as desired destinations and arrival times. Heuristic algorithms will be developed and existing databases effectively used to produce Itinerary Planner prototypes. The Planner will aid in promoting public transit and ridesharing for non-commute trips.



#### **Evaluation of TRANSCAL Field Operational Test**

*Paul Jovanis, Civil Engineering, UC Davis*

These goals are proposed: 1) Assessment of user acceptance of the technology, specifically recognizing different potential user groups. 2) Thorough identification and assessment of system benefits and costs. 3) Demonstration of the technological feasibility of the system by testing it over the life of the project. 4) Study of changes in the demand for travel and the travel patterns of individuals participating in the project. 5) Assessment and description of institutional arrangements necessary for sustained operation of TRANSCAL.

#### **Evaluation of TravInfo Field Operational Test**

*Y.B. Yim, PATH Headquarters*

The project will continue to support the evaluation of the TravInfo field operational test. It covers part of the overall project management, institutional, and traveler response portion of the evaluation.

## **Event-based Advanced Traveler Information Systems (ATIS): Practical Implementation and Evaluation of Optimized Strategies**

*R. Jayakrishnan, Civil Engineering, UC Irvine*

This project will further adapt and enhance previous research of relevance to event-based Advanced Traveler Information Systems (ATIS) and implement the algorithms for traffic management in Anaheim. It will generate traffic rerouting plans for changeable message signs and Highway Advisory Radio.

## **Finding Tractable Ways to Alleviate System-Made Congestion in Large Scale Networks**

*Raja Sengupta, PATH Headquarters*

It is suspected that the introduction of Advanced Traveler Information Systems (ATIS) services may actually worsen congestion in some traffic conditions: this is "system-made congestion." Our aim is to characterize some of these conditions and investigate ways in which ATIS services may be modified to avoid these counterproductive effects.

## **Provision of Traffic Information - A Study of Supply and Market Structure**

*Adib Kanafani, Institute of Transportation Studies, UC Berkeley; Pravin Varaiya, Electrical Engineering and Computer Sciences, UC Berkeley, PATH Headquarters*

The purpose of this research is to understand the structure of the market for traffic information, particularly the supply of information by private and public providers. It will develop a comprehensive model of private and public information provision, and of the organization of the market in which information is acquired and disseminated to end users or value-added resellers.

## **Traffic Information: Value, Production, and Use**

*Adib Kanafani, Institute of Transportation Studies, UC Berkeley*

Develops an economic theory of Advanced Transportation Information Systems (ATIS) that incorporates three elements: the value of information to travelers and traffic managers; the technologies for collecting and disseminating information; and, the competitive arrangements among enterprises (private and public) that provide this information.

### **• Human Factors**

## **Alternative Traffic Signal Illumination: A Human Factor Study**

*Theodore Cohn, Optometry, UC Berkeley*

Using advanced psychophysical methods, this project examines the visual effects of a range of possible energy and maintenance cost saving alternatives to standard incandescent traffic signal lamps in order to see whether new alternative lamps convey the same safety information as their expensive predecessors.

## **■ ATMS (Advanced Transportation Management Systems)**

### **• Evaluation and Testing**

## **Evaluation of Freeway Service Patrol (FSP) at a Los Angeles Freeway Site – Phase II**

*Alexander Skabardonis, Institute of Transportation Studies, UC Berkeley*

Evaluates the costs/benefits of the Freeway Service Patrol on a specific beat in the Los Angeles freeway system, continuing the work of previous research. Also develops a comprehensive database on freeway operating conditions similar to the one developed for the I-880 test site.

## **Evaluating System ATMS Technologies Via Rapid Estimation of Network Flows**

*James E. Moore II, Civil Engineering and Urban Planning and Development, University of Southern California*

Uses associative memories to make rapid estimates of flows for the Los Angeles (Caltrans District 7) freeway network. It uses empirical flows observed following the opening of the Glen Anderson 105 freeway after the 1994 Northridge earthquake, and following the incremental repair of facilities. Good estimates of large scale network flows can be produced very inexpensively for different network configurations, thus making it possible to incorporate system effects into bridge retrofit decisions.





### Mobile Surveillance Field Operational Test (FOT)

*Stephen Hockaday, California Polytechnic State University, San Luis Obispo*

Evaluation of mobile surveillance FOT for video imaging processing, vehicle roadside communication systems, and transportable ramp metering system employing spread spectrum radio. Test is in real-world conditions on Orange County freeways and arterials.

### Rapid Evaluations of Field Tests

*Robert Tam, PATH Headquarters; C. Arthur MacCarley, Electronic/Electrical Engineering, California Polytechnic State University, San Luis Obispo*

This project involves two tests. The first is a field test of a fog detector system for Caltrans District 10 in Stockton.; the second, a feasibility study of a video-based surveillance system.

### Research, Development, and Testing of Roadway Surveillance Technologies

*Harry Cheng, Mechanical and Aerospace Engineering, UC Davis; Wei-Hua Lin, Robert Tam, PATH Headquarters*

We are developing a nonintrusive detection system for measuring the true travel time of a platoon of vehicles on a highway. The key to this measurement is to acquire unique or semi-unique information on vehicles and then reidentify them downstream. To do this, we will develop a laser-based vehicle identification system that can obtain high-resolution, reproducible, site-independent delineations of vehicles.

### TRICEPS: An ATMIS Field Implementation for Control and Evaluation

*Michael G. McNally, Institute of Transportation Studies, R. Jayakrishnan, Civil Engineering, K. Kim, Electrical and Computer Sciences, UC Irvine*

The Testbed Real-time Integrated Control and Evaluation Prototype System (TRICEPS) is a software platform that facilitates the testing and evaluation of a wide range of algorithms for adaptive traffic management and control, using traffic system data from external sources. We are adapting TRICEPS for use with real-world data from real-time connections with transportation facilities in the Irvine, California Freeway and Arterial Adaptive Control Field Operational Test.

### Use of Los Angeles Freeway Service Patrol (FSP) Vehicles as Probe Vehicles

*James E. Moore, II, Civil Engineering and Urban Planning and Development, University of Southern California*

This research focuses on the feasibility of using the existing telemetry and Mobile Data Terminals (MDT) installed on Los Angeles Freeway Service Patrol vehicles to enable FSP tow trucks to be used as probe vehicles when cruising. Combining single trap loop detector counts with probe vehicle data would improve speed estimates considerably.

### • Incident Management

### Development Testing and Evaluation of Advanced Techniques for Freeway Incident Detection

*Stephen Ritchie, Institute of Transportation Studies, Civil and Environmental Engineering, UC Irvine*

The techniques examined are based on a common database containing actual incident data. Approaches include neural networks from the field of artificial intelligence, filtering methods for preprocessing traffic data (to reduce the likelihood of false incident decisions from unexpected, short-duration traffic disturbances), and algorithms derived from consideration of catastrophe theory concepts applied to freeway traffic flows.

### • Signal Control

### Evaluation of the City of Anaheim Advanced Traffic Control System Field Operational Test (FOT)

*C. Arthur MacCarley, Electronic/Electrical Engineering, California Polytechnic State University, San Luis Obispo; James E. Moore II, Civil Engineering and Urban Planning and Development, University of Southern California; Michael G. McNally, Institute of Transportation Studies, UC Irvine*

A systematic evaluation of the performance and effectiveness of this FOT. The test has two key technical features: arterial traffic control supervised by the SCOOT (Split Cycle and Offset Optimization Technique) algorithm, and a VTDS (Video Traffic Detection System) developed by Odetics Corporation.



## Evaluation of the City of Irvine Integrated Freeway Ramp Meter/Arterial Adaptive Signal Control Field Operational Test (FOT)

*C. Arthur MacCarley, Electronic/Electrical Engineering, California Polytechnic State University, San Luis Obispo; James E. Moore II, Civil Engineering and Urban Planning and Development, University of Southern California; R. Jayakrishnan, Civil Engineering, Michael G. McNally, Institute of Transportation Studies, UC Irvine*

A systematic evaluation of the performance and effectiveness of this FOT. The Irvine FOT involves an integrated and jointly managed Advanced Transportation Management System (ATMS) that extends the capabilities of the existing freeway and arterial traffic management systems in the Irvine area of Orange County. The primary objective is to integrate and coordinate a centrally controlled freeway Ramp Meter System (RMS) with an arterial traffic management system.

## Impacts of Various Signal Coordination Approaches

*Wei-Hua Lin, PATH Headquarters; Alex Skarbardonis, Institute of Transportation Studies, UC Berkeley*

Signal coordination is often considered as an essential tool for traffic congestion mitigation. Since it requires many detectors and equipment, it is important to determine its cost-effectiveness. This study seeks to examine the impacts of various signal coordination approaches. It highlights the various assumptions adopted in the different approaches, and uses a simulation platform to validate the assumptions and evaluate their associated impacts.

## Machine-Vision Based Vehicle-Actuated Traffic Signal Controller

*Mike Cassidy, Institute of Transportation Studies, UC Berkeley*

We are assessing the impacts of applying machine-vision detection systems to control signalized intersections. Unlike existing control systems, which often rely on "point" detectors to infer queuing conditions, a machine-vision system will utilize information about conditions at all points on the intersection approaches. Our controller will utilize measured vehicle information in all directions from above the intersection. We anticipate reductions in motorist delays, and improved safety.



### • Surveillance

## Estimation of Travel Time Distribution and Detection of Incidents Based on Automatic Vehicle Classification

*Venkat Anantharam, Electrical Engineering and Computer Science, UC Berkeley*

Automatic vehicle classification is feasible with current vehicle detector technology. The goal of this research is to develop pattern-matching algorithms that use data from several detectors deployed along a freeway section to yield estimates of the travel-time distribution of vehicles, and indicators of congestion and incidents.

## Machine Vision Based Surveillance for Advanced Monitoring of Highways and Drivers

*Jitendra Malik, Stuart Russell, Electrical Engineering and Computer Science, UC Berkeley*

This system uses state-of-the-art image processing and tracking algorithms in an attempt to attain higher levels of accuracy and reliability than have yet been achieved in real-time ATMIS surveillance. It detects vehicles on the road, tracks their progress through the camera's field of view, and identifies each vehicle by generic type (car, van, truck, etc.). The system will provide traffic counts and speeds, track lane changes, and alert for unusual traffic conditions.



## Section Related Measures of Traffic-System Performance

*Stephen Ritchie, Institute of Transportation Studies, Civil and Environmental Engineering, UC Irvine*

Demonstrates and evaluates new methods for obtaining true "section-related" performance measures, initially for freeways, based on pattern recognition technology and the use of either existing loop detectors or overhead mounted infrared sensors. Results will help determine potential benefits of applying these techniques to congestion monitoring, incident detection, traveler information, and system performance measures.

## Study of Advanced Image Sensing Methods for Traffic Surveillance and Hazard Detection

*C. Arthur MacCarley, Electronic/Electrical Engineering, California Polytechnic State University, San Luis Obispo*

A study of alternative imaging technologies for traffic surveillance and detection that have superior ability to "see" through fog and particles, or that do not depend on visible-spectrum illumination.

### • Traffic Modeling

## Data For Transportation Modeling in the Smart Corridor

*Joy W. Dahlgren, PATH Headquarters*

This project is part of a larger project that includes "Incident Response Modeling for the San Francisco Bay Area." It includes inventorying data currently available for modeling the corridor. For required data that is not now available, a work plan and cost estimates for obtaining data will be developed. The plan will include data collection, processing, transmission and storage.

## Simulation Models of Driver-Vehicle Interactions

*Alexander Skabardonis, Institute of Transportation Studies, UC Berkeley*

This study will develop improved car-following and lane changing models for highway traffic. The models' formulation will consider interactions between car-following and lane changing, driver behavior under different operating conditions, and variability in driver-vehicle characteristics. The improved models will be incorporated into an operational simulation model and will be calibrated and validated with field data.

## AVCSS

(Advanced Vehicle Control and Safety Systems)

### Enabling Technologies

## Global Positioning System/Inertial Navigation System (GPS/INS) Based Lateral and Longitudinal Control

*Jay Farrell, College of Engineering, Matthew J. Barth, Center for Environmental Research and Technology, UC Riverside; Randy Galijan, SRI International*

Our objective is to develop and demonstrate Differential Global Positioning System (DGPS) technology in conjunction with an Inertial Navigation System (INS). DGPS/INS can potentially determine a vehicle's position to the centimeter, without significant changes to highway infrastructure. Knowledge of vehicles' absolute position will permit the use of significantly more of the path preview information needed for high performance Advanced Vehicle Control and Safety Systems (AVCSS) than would be possible using only relative position reference systems; significantly improving control performance.

## Field Test of Vehicle-Mounted Forward-Looking Range and Relative Velocity Sensor in Closed-Loop Advanced Vehicle Control and Safety Systems (AVCSS)

*Petros Ioannou, Center for Advanced Transportation Technologies, University of Southern California; Lon E. Bell, Amerigon, Inc.*

Amerigon, a small company in the Los Angeles area, has designed Integrated Domain Radar (IDR), taking advantage of a novel ultra-wideband radar sensor technology (developed for use in triggering air bags) to create low-cost devices to measure spacing to other vehicles. USC will evaluate IDR's potential as a primary longitudinal sensor for AVCSS applications.

## Integrated Microsensors for Vehicle Control

*Bernhard E. Boser, Roger Howe Electrical Engineering and Computer Sciences, UC Berkeley*

Collaboration with PATH engineers enables us to characterize the drift, linearity, and cross-axis sensitivity of commercial and research accelerometers, closing the loop between sensor design and application. One result is a monolithic z-axis accelerometer built in a single-layer polysilicon technology. Our findings will be applied to the design of a monolithic low-drift 3-axis accelerometer to be fabricated and tested at the end of the proposal period.



## Investigation of an Optical Method to Determine the Presence of Ice on Road Surfaces

*Jim Misener, PATH Headquarters*

An exploratory study to determine the feasibility of a remote sensing system to detect the presence of water or ice on a roadway surface. If this study shows basic feasibility, it could lead to future development of either roadside or vehicle-mounted optical sensors to estimate tire/road traction and thereby improve safety.



### Evaluation

## Aerodynamic Studies of Short Headway Platoons

*Frederick Browand, Aerospace Engineering, University of Southern California*

Wind-tunnel testing of 1/8 scale GM APV vans in platoons of two, three, and four vehicles in the Dryden Wind Tunnel at USC to determine the drag, side force, and yawing moment that acts on various vehicles. Drag is shown to depend strongly upon intervehicle spacing, implying that fuel economy can be improved by appropriate separation distances. Full-scale vehicle tests under more realistic conditions will be performed to verify the wind-tunnel results.

## AHS Deployment: Site Selection, Phasing and Institutional Arrangements

*Randolph Hall, Industrial and Systems Engineering, University of Southern California; Thomas Horan, Claremont Graduate School*

Automated Highway Systems will probably be deployed in incremental steps, both with respect to vehicle electronics and supporting roadway infrastructure. One of the first steps in this path will be completion of field operational tests of automation technology. This project is evaluating alternative sites for AHS field operational tests, and working to develop evaluation criteria and system characteristics.

## Development and Experiment Evaluation of Autonomous Vehicles for Roadway/Vehicle Cooperative Driving

*Petros Ioannou, Center for Advanced Transportation Technologies, University of Southern California*

A study of Autonomous Intelligent Cruise Control (AICC) systems as part of an intelligent roadway/vehicle system in which the AICC controls vehicle longitudinal following while the roadway commands vehicle speeds and intervehicle spacings. Research concentrates on developing and selecting control algorithms for the vehicle and roadway, then analyzing them for robustness using computer simulations and full-scale PATH test vehicles.



## Evaluation of Alternative AHS System Operating Concepts

*Carlos Daganzo, Civil Engineering, Michael Cassidy, Institute of Transportation Studies, UC Berkeley*

Automated vehicles can travel on all lanes, but non-automated vehicles cannot. This project develops a macroscopic theory and associated computer software to predict the effect transient phenomena such as disruptions to flow in automated and non-automated lanes may have on ITS system performance. Success in this endeavor will assist in the design of the interface of an AHS with the conventional highway network, and in the development of effective measures to handle disruptions to flow.

## Models of Vehicular Collision: Development and Simulation with Emphasis on Safety

*Oliver M. O'Reilly, Panos Papadopoulos, Mechanical Engineering, UC Berkeley*

The objective is the development of simple predictive models for vehicular impacts and collisions, models that will be capable of capturing in an averaged sense the basic response characteristics of the vehicular motion. These models will serve as a testing ground for the computational simulations and safety analysis of platoon dynamics.

## Persistence and Query Interpretation for SmartAHS

*Aleks Gollu, PATH Headquarters*

Focuses on design and implementation of a query interpreter and also of simulation check printing and component tracing, three specific features of SmartAHS, a design, specification, simulation, and evaluation framework for highway implementation architectures.

### Transient Aerodynamic Vehicle Interactions

*Omer Savas, Mechanical Engineering, UC Berkeley*

Continues experimental evaluation of transient aerodynamic effects on automated vehicles, using 1/8 scale model vehicles in a wind tunnel. The effects of transient vehicle movements, such as lane changes, are tested to ensure that we understand the effects that aerodynamics will have on the performance of vehicles. The results will provide essential input to the control system designers so that they can ensure that the vehicle control systems will be able to maintain effective and safe performance at all times, including when the traffic stream includes a mixture of diverse vehicles.

### Safety

#### Emergency Vehicle Maneuvers and Control Laws (EVMCL) for Automated Highway Systems (AHS)

*Roberto Horowitz, Mechanical Engineering; Shankar Sastry, Electrical Engineering and Computer Sciences, UC Berkeley*

In this project we will deal with the operation of vehicles such as police cars and ambulances in Automated Highway Systems. We plan to design, analyze, verify, and test in Smartpath the maneuvers and control laws needed for the regulation, coordination and link layers of the PATH control architecture to allow the entrance, transit, operation, and exit of such vehicles under emergency conditions.



#### Evaluation of Work Crew and Highway Hazard Conspicuity

*Jim Misener, PATH Headquarters*

This project applies a state-of-the-art analysis approach developed by the US Army to evaluate and develop recommendations for improving the conspicuity of potential roadway hazards such as Caltrans work crews, signs, and roadside appurtenances. Based on the best current knowledge of human visual capabilities, it can potentially lead to improvements in the safety of California's roads and road workers.

#### Fault Detection and Identification with Application to Advanced Vehicle Control Systems

*Jason L. Speyer, Mechanical, Aerospace, and Nuclear Engineering, University of California, Los Angeles*

Conclusion of a project aimed at improving the fault-tolerance of advanced vehicle control systems by developing and applying fault detection and identification technology, using an analytic redundancy scheme known as a detection filter. Goals: 1) improve the filter's robustness by better accounting for disturbances, sensor noise, and modeling errors 2) describe the statistical properties of filter output 3) develop a fault identification system where several detection filters operate in parallel.

#### Integration of Fault Detection and Identification into a Fault Tolerant Automated Highway Systems

*Jason L. Speyer, Mechanical, Aerospace, and Nuclear Engineering, University of California, Los Angeles*

Fault detection and identification methods developed earlier will be extended and combined with the results of work by other researchers to develop a comprehensive, fault tolerant control system that can be verified in subsequent work. This is needed in order to ensure that vehicle automation systems can be developed with viable combinations of safety, performance and cost.

#### Intelligent Diagnosis Based on Validated Fused Sensor Data for Reliability and Safety Enhancement of Automated Vehicles in an Intelligent Transportation System (ITS)

*Alice Agogino, Kai Goebel, Mechanical Engineering, UC Berkeley*

This completes a project on intelligent diagnosis based on validated fused sensor data for reliability and safety enhancement of automated vehicles. Specifically, research to analyze modules, intelligent diagnosis, hazard analysis and safety decision maker which takes the validated and fused sensor data as input and gives probabilities of hazards as output.





## Models of Vehicular Collision: Development and Simulation with Emphasis on Safety

*Oliver M. O'Reilly, Panos Papadopoulos, Mechanical Engineering, UC Berkeley*

The objective is the development of simple predictive models for vehicular impacts and collisions, models that will be capable of capturing in an averaged sense the basic response characteristics of the vehicular motion. These models will serve as a testing ground for the computational simulations and safety analysis of platoon dynamics.

## Safety Analysis of Automated Highway Systems

*Nancy Leveson, Computer Science and Engineering, University of Washington*

The introduction of computer control into electromechanical systems has created new and unsolved problems for both system and software engineers. Our research involves taking system safety approaches that have been developed and proven successful in the defense and aerospace arenas and adapting them to automated highway problems. Our objective is to develop an integrated set of safety analysis procedures to validate system safety in computer-controlled systems.

## Safety Analysis of Concept Systems for Guidance and Control of Transit Buses

*James Bret Michael, PATH Headquarters*

Studies the safety of one of the most promising early-stage AVCSS systems, which would provide guidance and possibly control to buses for precision docking at high-level platforms to permit easy access by elderly and handicapped riders. It builds on extensive prior experience by PATH partners at INRETS in France and Honeywell.

## Safety Evaluation of Vehicle Following Operations by Fault Tree Sensitivity Analysis

*Ching-Yao Chan, James Bret Michael, Andy Segal, PATH Headquarters*

The objective is to use fault tree and other safety tools to evaluate safety issues in vehicle following operations. The project focuses on causes of potential failures, and vehicle behavior under abnormal conditions. Factors to be addressed include platoon dynamics, vehicle engine dynamics, sensors and actuators, communication systems, and control algorithms.

## Studies of Collisions in Vehicle Following Operations by Two-Dimensional Impact Simulation

*Ching-Yao Chan, PATH Headquarters*

Analyzes vehicle trajectories in different collision scenarios using a two-dimensional crash simulation program. The simulation includes translational and rotational motions of two vehicles and impact forces. The effects of operating variables, such as speed, vehicle size, spacing and lateral offset on post-impact motions are evaluated. Safety consequences and hazards of failure events are studied, and control strategies are contemplated.

## Verifying and Validating Critical Real-Time Vehicle Control Software

*Andy Segal, PATH Headquarters*

Extends results of a previous study, using the latest lateral and longitudinal software and software analysis tools. Focuses on the software embedded in PATH's experimental system for lateral and longitudinal control of a vehicle. Scope includes analysis of the existing software, testing of the software to determine failure modes, and vehicle testing to validate the conclusions drawn from analysis and testing.

## ■ System Design

### AHS Network Layer Design for SmartPath

*Pravin Varaiya, Electrical Engineering and Computer Science, UC Berkeley, PATH Headquarters*

This project concerns the development of the network layer, the highest layer of a four layer hierarchical control architecture for an Automated Highway System (AHS). We will develop a network layer model, the interface between the network and link layer, and a computer model of the network layer in SmartPath.





### **Design and Evaluation of an AHS with Optimized Lane Assignments**

*Randolph Hall, Industrial and Systems Engineering, University of Southern California*

To obtain the maximum benefits of automated highways, it will be important to minimize the amount of lane changing, and to ensure that lane changing does not disrupt the flow of through traffic. This project has created two linear programming models to optimize the assignment of traffic to lanes, and to estimate capacity losses due to lane changing.

### **Design of Fault Tolerant Control Systems for AHS: Fault Detection, Fault Handling and Verification**

*Shankar Sastry, Electrical Engineering and Computer Sciences, Roberto Horowitz, Mechanical Engineering, Karl Hedrick, Mechanical Engineering, UC Berkeley*

Prior work has shown how vehicle control systems can be designed to work extremely well under normal conditions. The important remaining challenges are to ensure that they work well enough when failures do occur that vehicle users can be assured of safety. This project aims at detecting failures and then proving that safety can be maintained even in the presence of failures.

### **Design of Safe Switched and Feedback Based Maneuvers for Vehicle Control Systems**

*Roberto Horowitz, Mechanical Engineering, UC Berkeley*

Consistent models of increased abstraction and stabilizing control laws are being formulated for the link and network layers of the PATH Automated Highway Systems (AHS) architecture. New tools are being developed for analyzing the dynamic and feedback interaction between these layers and the coordination and regulation layers. Feedback based control laws for platoon leaders, and the switching between them, will be designed to guarantee safety under normal or degraded modes of operation.

### **Evaluation and Analysis of Automated Highway System Concepts and Architecture**

*Petros Ioannou, Center for Advanced Transportation Technologies, University of Southern California*

An ongoing project to predict the spacings that can be used between automated vehicles in order to improve both throughput and safety. Issues such as lane-change maneuvers, roadside traffic flow control, and synchronization of maneuvers by different vehicles are considered here, so that differences among different approaches to vehicle automation can be better understood.

### **Evaluation of Mixed Automated/Manual Traffic**

*Petros Ioannou, Center for Advanced Transportation Technologies, University of Southern California*

This project addresses one of the most controversial issues in the field of vehicle automation: whether automated vehicles should be designed to operate in mixed traffic (i.e., mixed in with manually driven vehicles). It also addresses the partial automation of driving functions, which may represent some intermediate stages leading toward the development of fully automated vehicles. By defining sensor, communication and control requirements, including consideration of man-machine interactions, this project is intended to make some progress beyond the conversational engineering that has characterized much previous consideration of these issues.

### **Verification of Automated Highway Systems (AHS) Vehicles Maneuver Design**

*Pravin Varaiya, Electrical Engineering and Computer Science, UC Berkeley*

PATH researchers have proposed a five-layer hierarchical control architecture for an Automated Highway System. The coordination layer plans and coordinates the maneuvers of a group of neighboring vehicles. This work develops hybrid systems models, well suited for computational treatment, to provide a computational framework in which the coordination and regulation layers can be formulated together and verification of maneuver designs can be facilitated as well.



## Vehicle Control

### Analysis, Design, and Evaluation of AVCSS for Heavy Duty Vehicles

*Ioannis Kanellakopoulos, Electrical Engineering, UC Los Angeles*

Due to their severe dynamic nonlinearities and actuator delays, and their low actuation-to-weight ratio, Commercial Heavy Vehicles (CHVs) are much harder to control efficiently than passenger cars. The longitudinal controllers designed in this project utilize nonlinearities and adaptation to achieve good performance with improved fuel efficiency, enhanced highway safety, and increased traffic flow.

### Brake System Modeling, Control and Integrated Brake/Throttle Switching

*Karl Hedrick, Mechanical Engineering, UC Berkeley*

Extends current work in brake modeling and control. Emphasis will be placed on developing adaptive control algorithms for robust brake control, based on models developed by this group in the past. Stability and convergence proofs of these algorithms will be developed, and experimental validation will complement their development. Brake torque will be measured directly and compared with the estimated values.

### Compatibility of Vehicles Within a Platoon

*Benson Tongue, Andrew Packard, Mechanical Engineering, UC Berkeley*

Examines how platoon operating parameters can be adjusted to account for non-uniform vehicles within the platoon. This will help ensure that vehicle control systems can get consistent performance from diverse vehicles mixed together closely.

### Development of Binocular Stereopsis for Vehicle Lateral Control and Obstacle Detection

*Jitendra Malik, Electrical Engineering and Computer Science, UC Berkeley*

This project aims at continual development of a machine-vision system for use in vehicle control, with emphasis on binocular stereopsis, and its integration with other sensors being developed in the PATH program.

### Development and Experiment Evaluation of Autonomous Vehicles for Roadway/Vehicle Cooperative Driving

*Petros Ioannou, Center for Advanced Transportation Technologies, University of Southern California*

A study of Autonomous Intelligent Cruise Control (AICC) systems as part of an intelligent roadway/vehicle system in which the AICC controls vehicle longitudinal following while the roadway commands vehicle speeds and intervehicle spacings. Research concentrates on developing and selecting control algorithms for the vehicle and roadway, then analyzing them for robustness using computer simulations and full-scale PATH test vehicles.

### Experimental Studies on High-Speed Vehicle Steering Control with Magnetic Marker Referencing System

*Han-Shue Tan, Satyajit Patwardhan, PATH Headquarters*

Focuses on how to conduct robust automatic vehicle steering controls at highway speeds based on a look-down lateral sensing system.

### Experimental Studies on Vehicle Lateral Control Systems

*Han-Shue Tan, Satyajit Patwardhan, PATH Headquarters*

These studies continue PATH efforts to experimentally investigate sensing and control techniques for vehicle lateral control as part of an integrated vehicle control system. The emphasis is on improving safety and robustness at highway speed. Work includes development of the following algorithms: robust lateral control, tire burst control, lane-change control, and vision based lateral control.

### Lateral Control of Heavy Duty Vehicles for Automated Highway Systems

*Masayoshi Tomizuka, Mechanical Engineering, UC Berkeley*

Studies the performance limitations as well as enhancements of the lateral control of heavy vehicles, using analysis, simulation and experimentation. Specific questions include 1) off tracking phenomena, 2) significance of the preview available due to the longer wheel base of heavy vehicles, 3) effect of the type and number of sensors on performance and robustness of controllers, and the effect of saturation of tire cornering forces.



## Longitudinal Control of Heavy Duty Vehicles: Experimental Evaluation

*Ioannis Kanellakopoulos, Electrical Engineering, UC Los Angeles*

The adaptive and nonlinear controllers designed in the research project "Analysis, Design, and Evaluation of AVCS for Heavy Duty Vehicles" for longitudinal control of automated Commercial Heavy Vehicles (CHVs) are evaluated first on very detailed models, in collaboration with CHV manufacturers, and then in full-scale vehicle experiments. An iterative process of data collection and subsequent control redesign is employed to enhance the robustness and practicality of the controllers, and to integrate their operation with the lateral controllers evaluated in the project "Lateral Control of Heavy Duty Vehicles for Automated Highway Systems."



## Steering and Braking Control of Heavy Duty Vehicles

*Masayoshi Tomizuka, Mechanical Engineering, UC Berkeley*

Characterizes the dynamic response of trucks and buses, identifies key system parameters, and develops control algorithms to achieve automatic guidance in the lateral direction. Articulated vehicle characteristics including roll and yaw instability are studied. The lateral controller uses the independent braking forces of the trailer in addition to the front wheel steering of the truck. Its effectiveness has been shown by simulation; a preliminary experimental study is planned to validate the simulation models.



## FHWA/Caltrans Cooperative Agreement for Longitudinal Control Research

*Steven E. Shladover, PATH Headquarters; Karl Hedrick, Mechanical Engineering, UC Berkeley*

Provides experimental and enabling technology support to research projects on longitudinal control, and to the National AHS Consortium's development activities. Includes development of performance and testing specifications for ranging sensors, vehicle-to-vehicle communication, and braking actuation systems, followed by testing and evaluation of candidate hardware. Also supports the development and maintenance of a common in-vehicle real-time control computer hardware and software environment for all PATH AVCSS test vehicles, as well as the full-scale testing of longitudinal control hardware and software on a platoon of up to four vehicles.

# SYSTEMS

## Architecture

### California System Architecture Study

*Thomas Horan, Claremont Graduate School*

This study continues to examine the relationship between the emerging national Intelligent Transportation Systems (ITS), systems architecture and architecture developments occurring in the State of California. The primary objective will be to ensure that system operators and implementers within the state can provide input into implementation strategies to ensure efficient deployment of the national architecture in California.

## General

### Cost and Benefit Analysis in Support of Advanced Transportation System (ATS) Management Decisions

*Stein Weissenberger, PATH Headquarters*

Develops and applies data on the performance, benefits, and costs of Advanced Transportation Systems (ATS). Data will be collected, evaluated and managed in a form that will assist Caltrans and partner agencies in planning, deploying, and managing elements of a cost-effective transportation system. Information will be developed in a form that will be understandable by an audience of varied technical sophistication.

### Definition and Measurement of the Performance of the Transportation System

*Joy W. Dahlgren, PATH Headquarters*

Performance measures related to the benefits and costs of the system are useful in 1) determining when there is a problem in the system, 2) selecting and designing actions to mitigate the problem, and 3) determining the effectiveness of actions that are imple-

mented. This project will develop a framework and methods for describing the overall efficiency of the transportation system and estimating the potential effectiveness of alternative actions that might be taken to improve effectiveness.

#### **Data For Measuring Performance**

*Joy W. Dahlgren, PATH Headquarters*

The performance measure framework established in the project "Definition and Measurement of the Performance of the Transportation System" will require data. This project will identify data needs; specify data formats; recommend methods for data collection, transmission, processing and storage, and analyze organizational arrangements for performing these tasks. It will include a description and analysis of performance of various surveillance devices.

#### **Database Environment for Fast Real-Time Simulation of Urban Traffic Networks**

*R. Jayakrishnan, Civil Engineering, UC Irvine*

Will develop the environment for using ATMIS simulation software developed under previous PATH projects for real-time traffic simulation and scenario analysis with feedback from the real urban network. The environment will utilize object-oriented databases.

#### **Identification and Prioritization of Environmentally Beneficial Intelligent Transportation Technologies**

*Daniel Sperling, Institute of Transportation Studies, UC Davis*

Analyzes the emissions and energy impacts associated with the deployment of a range of ITS technologies and systems. Results can be used to formulate strategies and designs to fast-track technologies with positive impacts, and to enhance the environmental attractiveness of those that yield little or no environmental benefits. The research approach involves policy and regulatory analysis, market research, and emissions and demand modeling.

#### **Object-Oriented Database for IVHS**

*Pravin Varaiya, Electrical Engineering and Computer Science, UC Berkeley, PATH Headquarters*

Develops an object-oriented database general enough to integrate traffic simulation packages, data sets, and computational tools. The purpose is to design, build and test a software environment with an open architecture that will greatly facilitate the use of these software elements. The object-oriented database will be implemented in the commercial database system Versant.

#### **Parallel Processing for Fast Traffic Flow Simulation in Real-Time Applications**

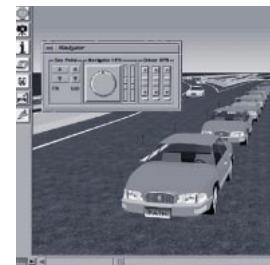
*R. Jayakrishnan, Civil Engineering, UC Irvine*

Develops techniques for fast simulation of traffic flow in urban networks using parallel processing. The focus is on the nature of traffic flow and its inherent ability to be parallelized. (Such speed-up is necessary for real-time simulations.) Explores alternative computational platforms for parallel processing and develops guidelines for considering the tradeoffs involved in terms of processing speed, ease of implementation, and to some extent the practical costs involved.

#### **PATH Center for Advanced Transportation Management Systems (ATMS) Research at UC Irvine**

*Wilfred Recker, Baher Abdulhai, UC Irvine*

The purpose of this research is to manage the UC Irvine ATMS Laboratory. Researchers will be responsible for software enhancements to the laboratory "benchtop" modeling system for modeling and evaluating ATMS.



#### **Planning**

#### **Beyond Telecommuting: The Travel/Communication Impacts of Advanced Telecommunications Services**

*Patricia L. Mokhtarian, Civil and Environmental Engineering, UC Davis*

Analyzes the impact of telecommunications-based information/transaction services on travel and communications. Data regarding changes in communication activities over time and on the use of a community network have been obtained and are being analyzed. The project will also gather information on existing and planned traveler information systems, and examine policy issues relevant to the questions of adoption and travel impacts of such systems.

## Decision Support Systems for Managing and Applying Intelligent Transportation Systems (ITS) Research

Joy Dahlgren, PATH Headquarters

Potential ITS implementors need information on the performance of ITS strategies, and ITS researchers need to know the extent to which these needs are unmet. This research will: 1) develop a system to communicate information to potential implementors, 2) determine unmet research needs, and 3) develop a method for selecting PATH research projects that will achieve the maximum public benefit.

## Deployment and Operation of Advanced Transportation Systems

Stein Weissenberger, PATH Headquarters

The goal of this research is to develop an understanding of how critical factors can effect the successful development, adoption, operation, and evolution of Intelligent Transportation Systems (ITS). The project will: 1) develop an analytical framework for describing, developing, and evaluating feasible ITS deployment strategies, 2) perform case studies of historical developments of technological systems with useful ITS parallels, and 3) develop strategic plans for several ITS deployments, ranging from the near-term (the Intelligent Transportation Infrastructure) to the far-term (Automated Highway Systems).

## ISTEA/ITS Connection in California: The State of the Relationship and Opportunities for Productive and Beneficial Linkages

Mark Miller, PATH Headquarters

What is the current state of California's plans for the development and implementation of intermodal, congestion, public transit, pavement, bridge, and safety management systems? To what extent has ITS been integrated within California's transportation planning process with respect to the development and implementation of these systems? Are there opportunities for integration that have not been recognized and implemented? The aim of this research is to answer these questions.

## Is There a Case for Public Investment in Telecommuting? The Cost/Benefit Analysis

Patricia L. Mokhtarian, Civil and Environmental Engineering, UC Davis

A formal economic evaluation of telecommuting, assessing the resulting transportation policy implications. The study involves reviewing the relevant cost-benefit and telecommuting literature, developing specific scenarios of home-based telecommuting adoption from both public- and private-sector perspectives, and evaluating the costs and benefits of the selected scenarios over the project life.

## Methodologies for Assessing the Impacts of Intelligent Transportation Systems and Conventional Highway Improvements on Travel Behavior

Joy W. Dahlgren, PATH Headquarters

Fears that capacity-enhancing ITS projects will increase travel proportionally may hamper implementation of such projects. This research will utilize recent and current conventional highway-capacity improvements to develop and evaluate methods for assessing the effects of capacity improvements on number of trips, departure times, routes, and modes.

## Traffic Management Systems

### Computer Integrated Transportation

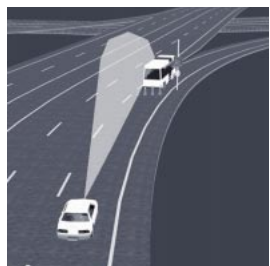
Randolph Hall, Industrial and Systems Engineering, University of Southern California

The project's objective is to identify the most effective role the State of California can serve in working with both public and private organizations within an integrated Intelligent Transportation System (ITS). The focus is on government/private sector relations in commercial vehicle transportation. After surveys, site visits, and focus groups with trucking companies around the state were completed, we concluded that trucking companies are willing and eager to invest and participate in projects with four basic characteristics: (1) modest investment, (2) no new taxes or fees, (3) promote operating efficiency, and (4) voluntary participation.

### Evaluation of Data Utilization in Traffic Management Centers (TMCs)

Wei-Hua Lin, PATH Headquarters

The overall objective is to improve efficiency in data utilization to support current TMC operations and future ATMIS deployment. Examines how sources of data can be effi-





ciently utilized in every specific TMC operation. Identifies weak links and information “gaps” in utilizing current data resources that support each of the TMC operations, and assesses the potential of integrating data that new technologies might make available in the near future (e.g. vehicle reidentification data, probe vehicle data) into the existing data framework.

#### **Incident Response Modeling for the San Francisco Bay Area**

*Baher Abdulhai, PATH Center for ATMS Research at UC Irvine; Stein Weissenberger, PATH Headquarters; Alex Skabardonis, Institute of Transportation Studies, UC Berkeley*

The goal of this project is to add a new, automatic process that would operate on and interpret the large amount of text-formatted California Highway Patrol Computer Aided Dispatch (CAD) information and extract Transportation Management Center (TMC)-relevant portions only. The system would produce audio-visual incident alarms, as well as filtered, prioritized recommendations to the TMC operators.

#### **Traffic Management Systems Performance Measurement**

*James H. Banks, Civil and Environmental Engineering, California State University, San Diego*

This project will develop measures of effectiveness for Caltrans Traffic Management Centers (TMCs) and their major functional responsibilities (ramp metering, incident management, ATIS, etc.) and will provide plans for improving TMC data collection and data management systems in support of performance measurement.









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*The 200 or so inquiring minds that make up PATH's research staff come from a variety of nations and academic backgrounds. Spread across six campuses of the University of California system, the California state university, other state universities, private colleges, and industry, they are united by the common goal of improving California's – and the world's – transportation systems.*



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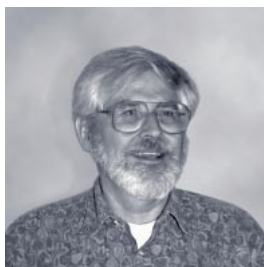
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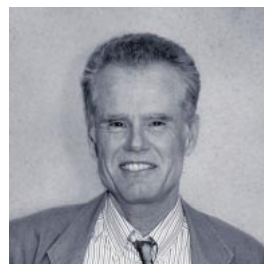
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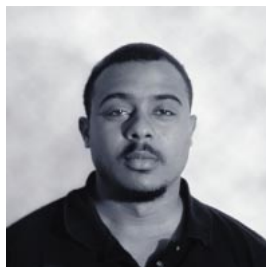
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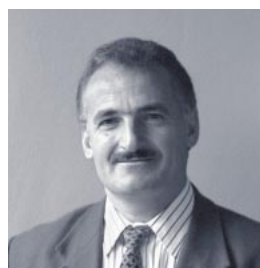


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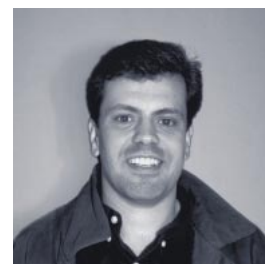
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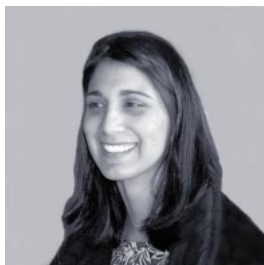


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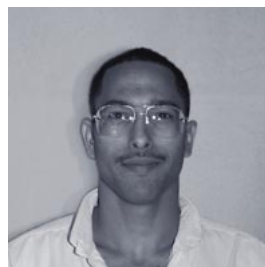
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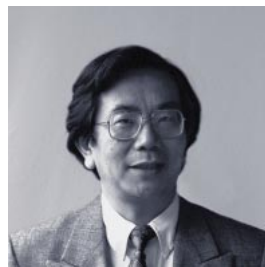
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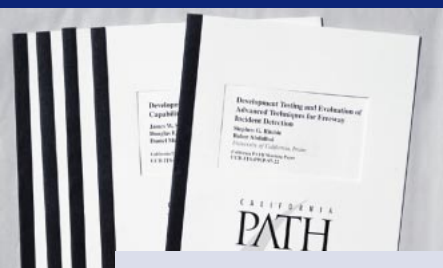
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## PATH PUBLICATIONS

### ATMIS

(Advanced Transportation Management Information Systems)

#### ■ APTS (Advanced Public Transportation Systems)

##### Advanced Public Transportation Systems: A Taxonomy and Commercial Availability

*Asad Khattak, Hisham Noeimi, Haitham Al-Deek, Randolph Hall*  
The main objectives of this study are to: 1) systematically classify new transit technologies and their impacts, 2) use the classification structure for exploring availability of new transit technologies, and 3) introduce technology developers to the California Advanced Public Transportation System (CAPTS) program.  
UCB-ITS-PRR-93-9  
August 1993, 95 pp, \$12.00

##### Assessment of IVHS-APTS Technology Impacts on Energy Consumption and Vehicle Emissions of Transit Bus Fleets

*Sylvan C. Jolibois, Jr., Adib Kanafani*  
The results invite skepticism about the benefits of APTS technologies insofar as pollutant emissions and fuel consumption are concerned. Recommendations are made about how technologies and services that can attract travelers from auto to transit without increasing bus miles should be emphasized.  
UCB-ITS-PRR-94-19  
August 1994, 20 pp, \$5.00

##### Development of User Needs and Functional Requirements for a Real-Time Ridesharing System

*Raghu Kowshik, John Gard, Jason Loo, Paul P. Jovanis, Ryuichi Kitamura*  
User needs are utilized to develop functional requirements for the proposed Real-Time Rideshare Matching system, and to identify services that should be provided by the system as well as interfaces to access the system.  
UCB-ITS-PWP-93-22  
December 1993, 35 pp, \$7.00

##### Evaluation of the Transit Information System in Southern California

*Emmanuel Le Colletier, Youngbin Yim, Randolph Hall*  
Study of the effectiveness of the transit telephone information system on trip behavior at Metropolitan Transit Authority (MTA), from both the user's and the operator's perspective.  
UCB-ITS-PRR-93-10  
August 1993, 80 pp, \$10.00

##### Improving Transit Performance with Advanced Public Transportation System Technologies

*Mark Hansen, Mohammad Qureshi, Daniel Rydzewski*  
Focuses on the attitudes and experiences of individual transit agency management, staff, and line personnel that are likely to determine their future choices with regard to APTS adoption and utilization. Proposes improvements to current adoption and utilization practices.  
UCB-ITS-PRR-94-18  
August 1994, 121 pp, \$15.00

##### Information and Institutional Inventory of California Transit Agencies

*Mark D. Hickman, Theodore Day*  
Identifies and investigates the current technical and institutional framework for information systems and technologies at public transit agencies in California. Examines current practice for collecting, using, and sharing data for operations monitoring, service planning, performance measurement and customer information. Draws some conclusions for improving agencies.  
UCB-ITS-PRR-96-12  
May 1996, 61 pp, \$15.00

##### Mass Transit Needs of a Non-Driving Disabled Population

*Reginald G. Golledge, C. Michael Costanzo, James R. Marston*  
Explores the activity patterns of blind and vision-impaired non-driving populations, evaluates impact of non-driving on employability and movement potential, discusses technologies to aid in making travel decisions and undertaking travel.  
UCB-ITS-PRR-96-9  
April 1996, 82 pp, \$20.00

##### Public Transit Use by Non-Driving Disabled Persons: the Case of the Blind and Vision Impaired

*Reginald G. Golledge, C. Michael Costanzo, James Marston*  
Survey results of blind and vision impaired non-driving public transit users are reported. Possible assistive technologies to aid in making travel decisions and undertaking travel are discussed.  
UCB-ITS-PWP-96-1  
January 1996, 10 pp, \$10.00

##### Travel, Emissions, and Consumer Benefits of Advanced Transit Technologies in the Sacramento Region

*Robert A. Johnston, Caroline J. Rodier*  
Effects of advanced transit technologies, including advanced transit information, demand responsive transit, and personal rapid transit, were simulated in the Sacramento region for a twenty year time horizon. Analysis showed that advanced transit information service alone produced the greatest increase in consumer welfare.  
UCB-ITS-PRR-96-24  
September 1996, 80 pp, \$15.00

#### ■ ATIS (Advanced Traveler Information Systems)

##### Bay Area ATIS Testbed Plan

*A. Khattak, H. Al-Deek, Y.B. Yim, Randolph Hall*  
The Bay Area ATIS (Advanced Traveler Information System) Testbed is a public/private partnership aimed at enabling wide-spread dissemination of real-time information on transportation conditions and travel options. This document presents the plan and procedures for conducting research within the Testbed.  
UCB-ITS-PRR-92-1  
September 1992, 81 pp, \$10.00

##### Behavioral Impacts of Recurring and Incident Congestion and Response to Advanced Traveler Information Systems in the Bay Area: An Overview

*Asad J. Khattak*  
Travelers' route, departure time and mode selection decisions in response to incident and recurring congestion

were investigated through a survey of Bay Area automobile commuters  
UCB-ITS-PWP-93-12  
September 1993, 74 pp, \$7.00

##### Collecting Road Traffic Data Using ALOHA Mobile Radio Channel

*Jean-Paul M.G. Linnartz, D.P. Gamba*  
Proposes a spectrum-efficient solution for transmitting link travel times from vehicles to a central infrastructure.  
UCB-ITS-PWP-93-9  
August 1993, 21 pp, \$5.00

##### Combined Traveler Behavior and System Performance Model with ATIS

*Asad Khattak, Haitham Al-Deek, Paramsothy Thananjeyan*  
Unique features are: integration of traveler behavior and system performance in the context of ATIS, exploration of unsaturated and over-saturated conditions, and investigation of the possibility of congesting alternate routes as well as the issue of user equilibrium.  
UCB-ITS-PRR-94-6  
March 1994, 55 pp, \$7.00

##### Commuters' Normal and Shift Decisions in Unexpected Congestion: Pre-Trip Response to Advanced Traveler Information Systems

*Asad Khattak, Amalia Polydoropoulou, Moshe Ben-Akiva*  
This survey of San Francisco Bay Area automobile commuters explores how people deal with unexpected congestion when they learn of it before starting a trip, and how they might respond to Advanced Traveler Information Systems (ATIS). Travelers' route, departure time, and mode selection decisions were investigated through stated preferences.  
UCB-ITS-PRR-96-7  
March 1996, 31 pp, \$20.00

##### Commuters' Normal and Shift Decisions in Unexpected Congestion: En Route Responses to Advanced Traveler Information Systems Volume 2

*Amalia Polydoropoulou, Moshe Ben-Akiva, Asad Khattak, Geoffrey Lauprete*  
Focuses on en-route travel response

to ATIS. Examines how travelers deal with unexpected congestion and how they might respond to qualitative, quantitative, prescriptive and predictive information obtained during a trip.  
UCB-ITS-PRR-96-21  
July 1996, 33 pp, \$33.00

**Concept of an Advanced Traveler Information System Testbed for the Bay Area: Research Issues**

*Asad J. Khattak, Haitham M. Al-Deek, Randolph W. Hall*  
The Bay Area ATIS testbed evaluation methodology is aimed at collecting, processing and enabling widespread dissemination of information on transportation condition and travel options. This paper discusses the TravInfo project and the Freeway Service Patrol evaluation project.  
Tech Note 94-6  
September 1994, 35 pp, \$7.00

**Custom Interface Builder Palettes for Advanced Driver Interface Rapid Prototyping**

*David W. Moore*  
A brief introduction to four classes of software objects developed to help a user create and test interfaces using these objects in the Interface Builder application environment.  
UCB-ITS-PWP-93-19  
November 1993, 11 pp, \$5.00

**Economics of Traffic Information: A State-of-the-Art Report**

*Matthew Malchow, Adib Kanafani, Pravin Varaiya*  
This preliminary review focuses on different methods used to model the decision process of drivers in a traffic system, and on the effect of traffic information on this process. The goal is to further understand the market for different types of traffic information.  
UCB-ITS-PWP-96-16  
October 1996, 24 pp, \$5.00

**Electronic Toll-Collection Systems (ETC) User Survey**

*Youngbin Yim*  
Summary of several surveys concerning the use of an electronic toll-collection system among San Francisco Bay Area motorists.  
UCB-ITS-PRR-91-12  
June 1991, 110 pp, \$12.00

**Expanding Usage of Cellular Phones: User Profile and Transportation Issues**

*Youngbin Yim, Adib Kanafani, Jean-Luc Ygnace*  
Assessment of a mail survey of GTE Mobilnet customers in the San Francisco Bay Area conducted to

assess the interrelationships between cellular communication and driver behavior.  
UCB-ITS-PRR-91-19  
December 1991, 79 pp, \$9.00

**Experimental Analysis and Modeling of Sequential Route Choice Under ATIS in a Simple Traffic Network**

*Kenneth M. Vaughn, Mohamed A. Abdel-Aty, Ryuichi Kitamura, Paul P. Jovanis, Hai Yang*  
Results indicate that drivers can rapidly identify the accuracy level of information being provided and that they adjust their behavior accordingly.  
UCB-ITS-PRR-93-12  
September 1993, 34 pp, \$7.00

**Exploration of Driver Route Choice with Advanced Traveler Information Using Neural Network Concepts**

*Hai Yang, Ryuichi Kitamura, Paul P. Jovanis, Kenneth M. Vaughn, Mohammed A. Abdel-Aty, Prasuna DVG Reddy*  
Results indicated that subjects made route choices based on their recent experiences and personal characteristics as well as the characteristics of the respective routes.  
UCB-ITS-PRR-93-13  
September 1993, 28 pp, \$5.00

**Feasibility Study of Advanced Technology HOV Systems. Volume 3: Benefit Implications of Alternative Policies for Including HOV Lanes in Route Guidance Networks**

*T. Chira-Chavala, W.H. Lin*  
Policy scenarios for including HOV lanes in dynamic route-guidance networks, when HOV lanes exist on the corridors.  
UCB-ITS-PRR-92-5  
December 1992, 56 pp, \$7.00

**Impact of ATIS on Drivers' Decisions and Route Choice: A Literature Review**

*Mohamed A. Abdel-Aty, Kenneth M. Vaughn, Ryuichi Kitamura, Paul P. Jovanis*  
Reviews the recent studies of drivers' behavior, and in particular their behavior when influenced by an Advanced Traveler Information System (ATIS).  
UCB-ITS-PRR-93-11  
September 1993, 44 pp, \$7.00

**Incident Management with Advanced Traveler Information Systems**

*Haitham Al-Deek, Adib Kanafani*  
A graphical queuing techniques model is utilized to define cases

when ATIS is beneficial and cases when it is not, also to evaluate its benefits as measured by travel time savings. Benefits to relevant parameters are also analyzed.  
UCB-ITS-PWP-91-5  
June 1991, 31 pp, \$5.00

**Message Volumes for Two Examples of Automated Freeway**

*Anthony Hitchcock*  
The volume of messages transmitted between vehicles, or between vehicles and the infrastructure, is calculated in order to estimate the demand of AVCS systems for frequency allocations.  
UCB-ITS-PRR-93-1  
March 1993, 17 pp, \$5.00

**Modeling the Behavior of Traffic Information Providers**

*Matthew Malchow, Adib Kanafani, Pravin Varaiya*  
The characteristics that make traffic information unique as a service good are discussed and exploited in two models to show how the behavior of information providers might differ from that of firms in a traditional market. Questions are addressed regarding the clustering of competing providers and the efficiency of the resulting output.  
UCB-ITS-PWP-97-5  
February 1997, 28 pp, \$10.00

**Models of Commuter Information Use and Route Choice**

*Mohamed A. Abdel-Aty, Kenneth M. Vaughn, Ryuichi Kitamura, Paul P. Jovanis, Fred L. Mannering*  
Based on a 1992 computer-aided telephone interview survey of Los Angeles area morning commuters. Results showed that only 15.5% of the respondents reported that they don't always follow the same exact route to work.  
UCB-ITS-PWP-93-21  
November 1993, 38 pp, \$7.00

**Potential Benefits of In-Vehicle Information Systems (IVIS): Demand and Incident Sensitivity Analysis**

*Haitham Al-Deek, Adolf May*  
The objective of this research is to conduct traffic demand and incident sensitivity analysis of benefits of IVIS by studying variations in demand levels, incident severity, and incident location.  
UCB-ITS-PRR-89-1  
May 1989, 88 pp, \$8.00

**Potential Benefits of In-Vehicle Information Systems in a Real Life Freeway Corridor Under Recurring and Incident-Induced Congestion**

*Haitham Al-Deek, Michael Martello, Adolf May, Wiley Sanders*  
This report presents use of the FREQ8PC program to simulate traffic on the Santa Monica Freeway corridor.  
UCB-ITS-PRR-88-2  
July 1988, 205 pp, \$23.00

**Research Plan for Highway Vehicle Navigation Technology**

*Geoffrey D. Gosling*  
Addresses navigation, communication, and control technology, benefits of improved vehicle navigation, system requirements, and design and implementation issues. Six near-term and ten follow-on projects are described.  
UCB-ITS-PWP-87-1  
December 1987, 51 pp, \$7.00

**Role of Advanced Traveler Information Systems in Incident Management**

*H.M. Al-Deek*  
Using an idealized traffic corridor and deterministic queuing methods, conditions under which route guidance information is useful are identified.  
UCB-ITS-PRR-92-12  
December 1992, 154 pp, \$17.00

**Some Theoretical Aspects of the Benefits of En-Route Vehicle Guidance (ERVG)**

*Haitham M. Al-Deek, Adib Kanafani*  
It is found that travel time savings of the order of 3-4% can be achieved from route guidance. Benefits are quite sensitive to city street speed. Route guidance benefits can be enhanced if information is customized to motorists on the basis of their origins and destinations.  
UCB-ITS-PRR-89-2  
August 1989, 51 pp, \$11.00

**Stated and Reported Route Diversion Behavior: Implications on the Benefits of ATIS**

*Asad Khattak, Adib Kanafani, Emmanuel Le Colletier*  
ATIS user benefits are estimated from a survey of commuting behavior undertaken in the San Francisco Bay Area in 1993. Both reported and stated response to unexpected congestion are used to determine the commuters who would directly benefit from qualitative, quantitative, predictive, and prescriptive ATIS information.  
UCB-ITS-PRR-94-13  
May 1994, 38 pp, \$7.00

### **Towards a Technology Assessment of Highway Navigation and Route Guidance**

*Adib Kanafani*

This technology has reached an advanced stage and is on the market in some forms. Needed is an assessment of driver response and network behavior to evaluate technical requirements and limitations.

UCB-ITS-PWP-87-6

December 1987, 15 pp, \$5.00

### **User Perceived Benefits with Navigation Systems**

*Herve Commelgnes*

Studies relative time savings between vehicles unequipped and equipped with route guidance and navigation systems, in particular, to what extent relative travel-time savings decrease as the percentage of equipped vehicles increases.

UCB-ITS-PWP-91-2

June 1991, 44 pp, \$7.00

### **Vehicle Navigation and Route Guidance Technologies: Push and Pull Factors Assessment**

*Jean-Luc Ygnace, Haitham Al-Deek, Paul Lavallee*

Analyzes the different conditions in the US, Europe, and Japan.

UCB-ITS-PRR-90-2

May 1990, 55 pp, \$7.00

### **■ ATMS (Advanced Transportation Management Systems)**

#### **Analysis of Arterial Street Data from the ATSAC System**

*Vinton W. Bacon, Jr., Adolf D. May*

This study is part of an effort to simulate the Santa Monica Freeway Corridor in Los Angeles using the INTEGRATION model.

UCB-ITS-PWP-93-11

August 1993, 67 pp, \$8.00

#### **California Transportation Management Centers — Part 1: Assessment of Existing Capabilities**

*Hong K. Lo, Randolph W. Hall, John R. Windover*

This document includes a brief overview of TMC development efforts, and results of in-depth interviews with personnel at all seven Caltrans TMCs and three city TMCs.

UCB-ITS-PWP-93-17

December 1993, 55 pp, \$7.00

#### **Control Strategies and Route Guidance in Signal Controlled Networks**

*Alexander Skabardonis*

Control and timing strategies to handle diverted traffic from the freeways to surface streets were

developed and tested through simulation on real-life networks.

UCB-ITS-PRR-91-20

August 1991, 46 pp, \$7.00

#### **Freeway Detector Data Analysis for Simulation of the Santa Monica Freeway—Initial Investigations**

*Loren D. Bloomberg, Vinton W. Bacon, Jr., Adolf D. May*

This analysis of vehicle detector data on the Santa Monica Freeway found that approximately 32 percent of the mainline freeway detectors appeared to give reasonable results.

UCB-ITS-PWP-93-1

August 1993, 31 pp, \$7.00

#### **Freeway Detector Data Analysis for Simulation of the Santa Monica Freeway—Summary Report**

*Loren D. Bloomberg, Adolf D. May*

Develops on/off ramp counts as input to a synthetic origin/destination model; strategies for synthesizing data from stations where current detector data are unavailable are also considered.

UCB-ITS-PWP-93-10

August 1993, 44 pp, \$7.00

#### **Freeway Service Patrol Evaluation**

*Alexander Skabardonis, Hisham*

*Noeimi, Karl Petty, Dan Rydzewski,*

*Pravin P. Varaiya, Haitham Al-Deek*

Presents the findings of a comprehensive evaluation of the freeway service patrol (FSP) program on a specific freeway section in the San Francisco Bay Area. Data were collected during the peak periods on a 1 mile section of the I-880 freeway in the City of Hayward, Alameda County, California.

UCB-ITS-PRR-95-5

February 1995, 140 pp, \$20.00

#### **Freeway Service Patrol (FSP) 1.1: The Analysis Software for the FSP Project.**

*Karl Petty*

Reference manual for the fsp program, a software tool used to interrogate the data collected during the Freeway Service Patrol Evaluation Project, and the xfsp program, a graphical user interface to the fsp program.

UCB-ITS-PRR-95-20

June 1995, 271 pp, \$35.00

#### **Incidents and Interventions on Freeways**

*Benjamin Heydecker*

Focuses on spatio-temporal aspects of congestion caused by an incident and how they can be alleviated by traffic management intervention. A

kinematic wave model of traffic is applied to investigate the issues of congestion.

UCB-ITS-PRR-94-5

February 1994, 39 pp, \$7.00

#### **Integration of Probe Vehicle and Induction Loop Data – Estimation of Travel Times and Automatic Incident Detection**

*Marcel Westerman, Remco Litjens, Jean-Paul Linnartz*

Methods for estimating travel times and performing automatic incident detection for ATMIS based solely on either induction loop or probe vehicle data are developed. The performance of the methods developed is shown to improve when additional traffic data from the other source is properly incorporated.

UCB-ITS-PRR-96-13

June 1996, 122 pp, \$20.00

#### **Investigating Intelligent Transportation Systems Strategies on the Santa Monica Freeway Corridor**

*Vinton W. Bacon Jr., John R. Windover, Adolf D. May*

Describes a multi-year research effort, involving a massive data collection effort, to simulate the Corridor using the INTEGRATION computer simulation model and to investigate potential benefits of ITS. Investigations indicate that ATIS benefits increase significantly with incident severity and significantly decrease with distorted information.

UCB-ITS-PRR-95-38

November 1995, 200 pp, \$30.00

#### **Investigating Intelligent Transportation Systems Strategies on the Santa Monica Freeway Corridor: Technical Appendix**

*Vinton W. Bacon Jr., John R. Windover, Adolf D. May*

Appendices for UCD-ITS-PRR-95-38

UCB-ITS-PRR-95-39

November 1995, \$35.00

#### **Machine Vision Based Surveillance System for California Roads**

*J. Malik, S. Russell*

Describes the successful combination of a low-level, vision-based surveillance system with a high-level, symbolic reasoner based on dynamic belief networks. Discusses the key tasks of the vision and reasoning components as well as their integration into a working prototype.

UCB-ITS-PRR-95-6

March 1995, 22 pp, \$5.00

#### **Neural Network Models for Automated Detection of Non-Recurring Congestion**

*Stephen G. Ritchie, Ruey L. Cheu*

Spatial and temporal traffic patterns are recognized and classified by an artificial neural network.

UCB-ITS-PRR-93-5

June 1993, 161 pp, \$18.00

#### **Organizing for IVHS: Computer Integration Transportation Phase 1: Results for Arterial and Highway Transportation Management Centers**

*Randolph W. Hall, Hong K. Lo, Erik Minge*

This study finds that four factors have profound implications for ITS implementation and research: time-frame, linking information to actions, broadcast orientation, and embracement of new technologies.

UCB-ITS-PRR-94-24

November 1994, 70 pp, \$9.00

#### **Organizing for ITS: Computer Integrated Transportation Phase 2: Results for Emergency Operations**

*Hong K. Lo, Holly Rybinski*

Examines emergency operations (EOs) in the San Francisco Bay Area, identifies their role in gathering and using traffic incident information, establishes the basis of coordination between EOs and TMCs, identifies possibly beneficial ITS services and technologies, and finally relates these EOs to the emerging ITS National Architecture.

UCB-ITS-PRR-96-11

May 1996, 42 pp, \$10.00

#### **Robust Computation of Optical Flow in a Multi-Scale Differential Framework**

*Joseph Weber, Jitendra Malik*

This approach to motion detection can be part of a real-time vision application system in which linear filters provide a basis for visual tasks such as passive ranging and moving object detection.

UCB-ITS-PWP-93-4

July 1993, 19 pp, \$5.00

#### **Robust Multiple Car Tracking with Occlusion Reasoning**

*Dieter Koller, Joseph Weber,*

*Jitendra Malik*

A new approach for detecting and tracking vehicles in road traffic scenes. High accuracy and reliability are obtained by using an explicit occlusion reasoning step, employing a contour tracker based on intensity and motion boundaries.

UCB-ITS-PWP-94-1

January 1994, 29 pp, \$5.00



### Simple Time Sequential Procedure for Predicting Freeway Incident Duration

Asad Khattak, Joseph L. Schofer, Mu-Han Wang

The authors first develop an understanding of factors that influence incident duration. A series of truncated regression models is used to predict incident duration. The implications of this simple methodology for incident duration prediction are discussed.

UCB-ITS-PRR-94-26

November 1994, 42 pp, \$7.00

### Time Space Diagrams for Thirteen Shock Waves

Benjamin Colfman

Presents microscopic time-space diagrams for several shock waves over 100-200m distances. The primary focus of the paper is on presenting the data rather than analysis. The diagrams should be of general interest to researchers studying traffic congestion.

UCB-ITS-PWP-97-1

January 1997, 21 pp, \$5.00

### Traffic Surveillance and Detection Technology Development: New Traffic Sensor Technology Final Report

Jitendra Malik, Stuart Russell

Examines new traffic sensor technology, mainly video cameras, for traffic surveillance and detection. Describes a Transportation Management Center (TMC) designed for collating and computing multisite statistics. Discusses tracking approach, motion-based grouping, tracking and grouping procedures, vehicle classification, hardware port, parameters computed at the TMC, testing methodology, and test results.

UCB-ITS-PRR-97-6

January 1997, 118 pp, \$20.00

### Variable Message Signs and Link Flow Evaluation: A Case Study of the Paris Region

Youngbin Yim, Jean-Luc Ygnace

Preliminary investigation of the effectiveness of the SIRIUS system in traffic management. Systeme d'Information Routiere Intelligible aux Usagers is the largest urban field operational test of an advanced traveler information and automated traffic management system in Europe.

UCB-ITS-PWP-95-5

May 1995, 46 pp, \$10.00

### Vehicle as Probes

Kumud K. Sanwal, Jean Walrand

Discusses the use of vehicles moving in traffic as probes that can report data on their speeds, locations, or travel times which can be used by

an algorithm to update estimates of traffic state and make predictions for the future.

UCB-ITS-PWP-95-11

August 1995, 26 pp, \$10.00

## AVCSS/AHS

### (Advanced Vehicle Control and Safety Systems and Automated Highway Systems)

#### ■ AHS Architecture

#### Assessing the Benefits of a National ITS Architecture

Mark Hickman, Stein Weissenberger, Joy Dahlgren

Principal beneficial features of the national architecture are: 1) a framework for system integration; 2) common data and functions; and, 3) open interface standards. These characteristics are likely to result in lower system costs and higher benefits for ITS users as well as product suppliers.

UCB-ITS-PWP-96-10

August 1996, 16 pp, \$5.00

#### Communication Architecture for IVHS

S. Streisand, J. Walrand

This paper documents the development of a layered architecture based on the OSI 7-layer reference model.

UCB-ITS-PRR-92-10

September 1992, 76 pp, \$9.00

#### Real Time Software Requirements for Vehicle Control Systems

David M. Auslander, An-Chyau Huang

This memorandum is intended as a means of unifying the software development among various PATH research groups, and, as such, as a focus for continuing discussion rather than a "solution."

TECH MEMO-92-2

August 1992, 21 pp, \$5.00

#### Sketch of an IVHS Systems Architecture

Pravin Varaiya, Steven Shladover

Presents a sketch of a system architecture for the control and management tasks of an intelligent vehicle/highway system (IVHS)

UCB-ITS-PRR-91-3

October 1990, 33 pp, \$5.00

#### Towards a Fault Tolerant AHS Design Part I: Extended Architecture

John Lygeros, Datta N. Godbole,

Mireille Broucke

Proposes a hierarchical control architecture for dealing with faults and adverse environmental condi-

tions on an Automated Highway System (AHS). A companion paper, abstracted in UCB-ITS-PRR-96-15, develops and verifies protocols for extended coordination strategies and maneuvers.

UCB-ITS-PRR-96-14

June 1996, 47 pp, \$5.00

#### Vehicle-Based Control Computer Systems

David M. Auslander

Describes a design and implementation methodology for real-time software suitable for control of mechanical systems such as vehicles. Explores methods for estimating velocity when the even rate from a digital encoder is lower than the controller's sample time.

UCB-ITS-PRR-95-3

January 1995, 56 pp, \$7.00

#### ■ AHS Collision and Safety Issues

#### Assessing the Safety Benefits of Automated Freeways

Mohammed Anwar, Paul P. Jovanis

This research is aimed at the identification of all types of accidents that have occurred on freeways that may affect vehicle movement in the assumed automated left lane.

UCB-ITS-PRR-93-29

December 1993, 59 pp, \$7.00

#### Casualties in Accidents Occurring During Split and Merger Maneuvers

Anthony Hitchcock

This paper explores conditions of reliability in split and merge maneuvers as part of an Automated Highway System (AHS). It also explores "follower's collisions" in an AHS.

TECH MEMO-93-9

November 1993, 13 pp, \$5.00

#### Coefficients of Friction and Automated Freeways

Anthony Hitchcock

Sets out some simple facts about the effects of the interaction between tires and the road insofar as it affects braking and forward acceleration. Attention is drawn to how AHS carriageways may wear differently from those on present-day freeways, and possible effects on braking capability.

Tech Note 94-1

February 1994, 6 pp, \$5.00

#### Collision Analysis of Vehicle Following Operations by Two-Dimensional Simulation Model: Part I – Effects of Operational Variables

Ching-Yao Chan

Analyzes the behavior of vehicles in collisions, using a two-dimensional simulation program that allows for

longitudinal, lateral, and yaw movements. Post-impact vehicle trajectories are then analyzed. By varying parameters, one can evaluate the potential effects of such variables in vehicle-following operations.

UCB-ITS-PRR-97-4

January 1997, 32 pp, \$10.00

#### Collision Analysis of Vehicle Following Operations by Two-Dimensional Simulation Model: Part II – Vehicle Trajectories with Follow-Up Maneuvers

Ching-Yao Chan

Discusses the effects of collisions in vehicle-following operations, using a two-dimensional simulation program that can fully represent translational and rotational movements. Scenarios where control actions are taken in post-impact conditions and the effects of these maneuvers on vehicle trajectories are investigated.

UCB-ITS-PRR-97-5

January 1997, 21 pp, \$10.00

#### Configuration and Maneuvers in Safety-Consciously Designed AHS Configuration

Anthony Hitchcock

Describes a configuration and operating principles for an Automated Highway System that is believed to have advantages from a safety viewpoint. The scheme requires that vehicles change lanes directly from platoon to platoon, and that entry and exit be made also without platoons merging or splitting on the automated lanes.

UCB-ITS-PWP-95-2

June 1995, 20 pp, \$5.00

#### Driving Safely in Smart Cars

Anuj Puri, Pravin Varaiya

Considers the issue of safety in Automated Vehicle Highway Systems (AVHS) and proposes an approach for proving that a system is safe. The authors contend that the problem of checking whether physical controllers in the vehicles satisfy safety constraints is equivalent to an optimal control problem.

UCB-ITS-PRR-95-24

July 1995, 17 pp, \$5.00

#### Entry to and Exit from a Safety-Consciously Designed AHS Configuration

Anthony Hitchcock

This paper proposes entry and exit maneuvers compatible with the automated highway system described in the author's paper "Configuration and Maneuvers in an Automated Highway System designed for Optimum Safety."

Tech Note 95-4

April 1995, 8 pp, \$5.00

### **Example of Quantitative Evaluation of AVCS Safety**

*Anthony Hitchcock*

A method for expressing in absolute terms the effect on safety of various features in the design of an AVCS system. Figures can be calculated for various degrees of injury, and variations in assumptions.

TECH MEMO-93-4

August 1993, 8 pp, \$5.00

### **Fault-Tree Analysis of an Automated Freeway with Vehicle-Borne Intelligence**

*Anthony Hitchcock*

Analysis of an automated freeway characterized by extreme emphasis on vehicle-borne intelligence, and by the presence of a multiplicity of automated lanes.

UCB-ITS-PRR-92-15

December 1992, 44 pp, \$7.00

### **Fault-Tree Analysis of a First Example Automated Freeway**

*Anthony Hitchcock*

How conformity to safety criteria can be demonstrated by fault-tree analysis.

UCB-ITS-PRR-91-14

June 1991, 51 pp, \$7.00

### **First Example Specification of an Automated Freeway**

*Anthony Hitchcock*

Specification for an automated freeway in a fully formal manner. A series of safety analyses have been carried out on the specification.

UCB-ITS-PRR-91-13

June 1991, 146 pp, \$16.00

### **Intelligent Vehicle Highway System Safety: Multiple Collisions in Automated Highway Systems**

*Anthony Hitchcock*

Compares casualty rates per failure on an automated highway system (AHS) according to the longitudinal control configuration used. The model used permits evaluation of the consequences of a failure, allowing for the multiple collisions that usually ensue.

UCB-ITS-PRR-95-10

April 1995, 31 pp, \$10.00

### **Layout, Design and Operation of a Safe Automated Highway System**

*Anthony Hitchcock*

For all accident types, there is one system which has casualties per incident no greater than 10% of its nearest rivals. This "preferred" system is described, and the predicted casualty rate results are quoted and discussed. If reliability of the control systems is sufficient, the advantages of the preferred system become unimportant.

UCB-ITS-PRR-95-11

April 1995, 26 pp, \$10.00

### **Low Speed Collision Dynamics: Second Year Report**

*Benson Tongue, Ahrie Moon, Doug Harriman*

Our goal is to develop a user-friendly simulation program to study platoon dynamics in both nominal and emergency scenarios. This report discusses issues investigated during the project's second phase, including inclusion of a vehicle model with an engine model, transmission model, a combined lateral and longitudinal controller, and a collision dynamics model.

UCB-ITS-PRR-96-8

April 1996, 42 pp, \$10.00

### **Methods of Analysis of IVHS Safety**

*Anthony Hitchcock*

Final report of a PATH project on developing and demonstrating methods by which the safety of Intelligent Vehicle Highway Systems (IVHS) can be assured, assessed and evaluated.

UCB-ITS-PRR-92-14

December 1992, 106 pp, \$12.00

### **Methods of Analysis of IVHS Safety - Executive Summary**

*Anthony Hitchcock*

Management and policy issues are briefly discussed in conclusion.

UCB-ITS-PRR-92-13

December 1992, 11 pp, \$5.00

### **Notes From a Talk on Standards and IVHS Safety**

*Anthony Hitchcock*

The author focuses on three distinct themes relevant to IVHS design and evaluation: 1) hazard analysis and the safety-critical subsystem; 2) design, verification, and validation of safety-critical software, and, 3) configuration management.

UCB-ITS-PWP-91-3

May 1991, 11 pp, \$5.00

### **Probabilistic Model and a Software Tool for AVCS Longitudinal Collision/Safety Analysis**

*H.-S. Tsao, Randolph Hall*

We use this model to compare the safety consequences associated with the platooning and "free-agent" vehicle-following rules.

UCB-ITS-PWP-93-2

June 1993, 23 pp, \$5.00

### **Safety and Efficiency Tradeoff Analysis for Automated Highway System: Part 3: Longitudinal Separation on AHS: A Trade-off between Collision Probability/Severity and Capacity**

*H.-S. Jacob Tsao, Randolph W. Hall*

Develops a probabilistic model for analyzing longitudinal collision/safety between an abruptly deceler-

ating vehicle and its immediate follower on an Automated Highway System. This model has many other applications.

UCB-ITS-PWP-97-8

February 1997, 21 pp, \$10.00

### **Specification of an Automated Freeway with Vehicle-Borne Intelligence**

*Anthony Hitchcock*

Derives a technique of safety analysis for an AHS by applying a procedure called fault tree analysis. The safety criterion used is that two or more simultaneous faults must occur independently before the hazards can arise.

UCB-ITS-PRR-92-18

December 1992, 142 pp, \$14.00

### **Use of NASS Data for Evaluation of AVCS Devices**

*Anthony Hitchcock*

In general, NASS raw data are useful for evaluation of AVCS whenever a driver's choices are limited to keeping a straight course at an appropriate speed.

UCB-ITS-PRR-91-8

July 1991, 12 pp, \$5.00

### **AHS-Degraded Modes of Operation**

### **Fault Detection and Identification with Application to Advanced Vehicle Control Systems**

*Randal K. Douglas, Jason L. Speyer, D. Lewis Mingori, Robert H. Chen, Durga P. Malladi, Walter H. Chung*

A preliminary design of a health monitoring system for automated vehicles is developed and results of tests in a high-fidelity nonlinear simulation are reported.

UCB-ITS-PRR-95-26

August 1995, 88 pp, \$15.00

### **Optimization Tools for Automated Vehicle Systems**

*Zvi Shiller*

Focuses on computing time-optimal maneuvers to develop strategies for emergency maneuvers and establishing a vehicle's performance envelope. The problem of emergency maneuvers is addressed in the context of time optimal control.

UCB-ITS-PWP-95-10

July 1995, 30 pp, \$10.00

### **Design of an Extended Architecture for Degraded Modes of Operation of AHS**

*John Lygeros, Datta N. Godbole, Mireille E. Broucke*

Proposes a hierarchical control architecture for dealing with faults and adverse environmental conditions on an Automated Highway System (AHS). The extended control strate-

gies needed by the supervisors of each layer of the hierarchy are outlined, and in certain cases, examples are given of their detailed operation.

UCB-ITS-PWP-95-3

April 1995, 31 pp, \$10.00

### **Design of Decentralized Adaptive Controllers for a Class of Interconnected Nonlinear Dynamical Systems: Part 1**

*Shahab Sheikholeslam, Charles A. Desoer*

We consider the class of interconnected nonlinear dynamical systems suggested by the problem of longitudinal control of a platoon of vehicles on automated highways and propose a control scheme in which these deviations are bounded independent of parameter errors.

TECH MEMO-92-1

February 1992, 37 pp, \$7.00

### **AHS Deployment**

### **Constraints on Initial AHS Deployment and the Concept Definition of a Shuttle Service for AHS Debut**

*H.-S. Jacob Tsao*

This paper proposes a shuttle van service as an initial stage for Automated Highway System deployment. While on the freeway, each van would be fully automated: on the street, a professional driver would take over.

UCB-ITS-PRR-96-5

February 1996, 24 pp, \$5.00

### **Driving Intelligence Replacement in a Decision-Oriented Deployment Framework for Driving Automation**

*H.-S. Jacob Tsao, Bin Ran*

This paper first defines the concept of AHS deployment. It then addresses the intelligence and skills involved in human driving on conventional highways. Finally, it proposes a decision-oriented deployment framework to replace human intelligence for automated driving.

UCB-ITS-PWP-96-4

June 1996, 12 pp, \$5.00

### **Formal Specification and Verification of the Entry and Exit Maneuvers**

*Sonia Sachs, Pravin Varaiya*

Studies deployment of an Automated Highway System (AHS), specifically the interface between an AHS and Urban Arteries (UA). Focuses on: 1) physical arrangement, operational procedures for entry/exit, 2) functions of transfer zone between the AHS and UA, 3) interaction between AHS and UA, and, 4) ways of controlling the interaction.

UCB-ITS-PRR-96-3

February 1996, 68 pp, \$15.00



### **Optimal Emergency Maneuvers of Automated Vehicles**

*Zvi Shiller, Satish Sundar*

Addresses two issues related to emergency maneuvers of autonomous vehicles. The first concerns time-optimal speeds along a specified path, which can be used to design emergency maneuvers. The second concerns the computation of optimal (shortest) lane-change maneuvers for on-line collision avoidance.

UCB-ITS-PRR-96-32

November 1996, 234 pp, \$30.00

### **Stage Definition for AHS Deployment and an AHS Evolutionary Scenario**

*H.-S. Jacob Tsao*

Proposes an approach to defining evolutionary scenarios for the deployment of an Automated Highway System (AHS). Six dimensions of deployment difficulties are identified: technology, infrastructure, human factors, vehicle manufacturing and maintenance, insurance, and public will.

UCB-ITS-PRR-96-4

February 1996, 27 pp, \$10.00

### **Symbolic Traffic Scene Analysis Using Dynamic Belief Networks**

*Tim Hagan, Gary Ogasawara, and Stuart Russell*

Describes traffic-scene analysis from the low-level processing of a traffic scene to its high-level description. Explains what dynamic belief networks are and some issues involved in using them for scene analysis.

TECH MEMO-93-8

November 1993, 6 pp, \$5.00

### **AHS Generals System Issues**

#### **AHS (Automated Highway System) Deployment: A Preliminary Assessment of Uncertainties**

*Randolph W. Hall, H.-S. Jacob Tsao*

Seven issues are addressed, concerning whether: 1) People use AHS, 2) Auto makers manufacture equipped vehicles, 3) Government builds AHS roadways, 4) Highways can evolve, 5) Interest groups do not obstruct, 6) Performance is adequate, and 7) Technology is feasible.

UCB-ITS-PWP-94-2

February 1994, 19 pp, \$5.00

#### **Are the Objectives and Solutions of Dynamic User-Equilibrium Models Always Consistent?**

*Wei-Hua Lin, Hong Lo*

Examines the general form of dynamic user-equilibrium traffic assignment (DUETA) models and shows that if queuing behavior is represented in the model at a minimal

level, the solution to conventional DUETA models may not necessarily converge to or approximate the Wardropian user-equilibrium condition in the dynamic sense.

UCB-ITS-PWP-96-6

June 1996, 14 pp, \$5.00

#### **Automated Highway Systems Operating Strategies and Events: A Driver's Perspective**

*H.-S. Jacob Tsao, Randolph Hall, Steven Shladover*

Major options are categorized as follows: separation of traffic, transitions between manual and automated driving, normal automated driving, and emergency response. Detailed operational events from the perspective of the driver are identified.

UCB-ITS-PWP-97-3

February 1997, 62 pp, \$15.00

#### **Comparable Systems Analysis of San Francisco's BART: Lessons for Automated Highway Systems**

*Mark D. Hickman*

Investigates both technical (safety, reliability, and maintenance) and non-technical (political pressure and public confidence) issues.

UCB-ITS-PWP-94-17

December 1994, 28 pp, \$5.00

#### **Conceptual Approach for Developing and Analyzing Alternate Evolutionary Deployment Strategies for Intelligent Vehicle/Highway Systems**

*Rokaya Al-Ayat, Randolph Hall*

Defines an evolutionary deployment sequence, identifies baseline assumptions, and presents strategies for achieving success.

UCB-ITS-PWP-94-5

March 1994, 47 pp, \$7.00

#### **Consumer Demand for Automated Private Travel: Extrapolations from Vanpool Users' Experience**

*Nirupa Bonanno, Daniel Sperling, Kenneth S. Kurani*

A focus group of existing vanpoolers was presented with the choice of driving alone or commuting with others.

UCB-ITS-PRR-93-17

November 1993, 71 pp, \$9.00

#### **Continuing Systems-level Evaluation of Automated Urban**

##### **Freeways: Year Three**

*Robert A. Johnston, Raju Ceerla*

This study demonstrated the travel and emissions impacts of urban freeway automation scenarios and compared these to travel demand reduction scenarios, such as travel pricing and land use intensification.

The Sacramento regional travel demand model set was used.

UCB-ITS-PRR-93-15

October 1993, 91 pp, \$10.00

#### **Design Options for Operation of Fully Automated Highway Systems**

*H.-S. Jacob Tsao, Randolph W. Hall, Steven E. Shladover*

Proposes six fully automated AHS operating scenarios featuring variations in three design options critical to the human factors of AHS operations.

TECH MEMO-93-3

February 1993, 37 pp, \$5.00

#### **Driving Intelligence Replacement in a Decision-Oriented Deployment Framework for Driving Automation**

*H.-S. Jacob Tsao, Bin Ran*

This paper first defines the concept of AHS deployment. It then addresses the intelligence and skills involved in human driving on conventional highways. Finally, it proposes a decision-oriented deployment framework to replace human intelligence for automated driving.

UCB-ITS-PWP-96-4

June 1996, 12 pp, \$5.00

#### **Functional Architecture for Automated Highway Traffic Planning**

*H.-S. Jacob Tsao*

This report defines an architecture for Automated Highway System (AHS) capacity-optimizing traffic planning functions. It identifies major traffic planning functions useful for optimizing the capacity of one or more major AHS operating scenarios and organizes them in a robust architecture that is modular, hierarchical, complete, expandable and integratable.

UCB-ITS-PRR-94-16

July 1994, 17 pp, \$5.00

#### **Longitudinal and Lateral Throughput on an Idealized Highway**

*Randolph W. Hall*

Uses deterministic approximations to model highway throughput. The model identifies conditions under which lane changes have an appreciable effect on capacity, assuming certain idealized conditions are met.

UCB-ITS-PWP-93-15

October 1993, 21 pp, \$5.00

#### **Major Failure Events of Automated Highway Systems: Three Scenarios from the Driver's Perspective**

*H.-S. Jacob Tsao, Thomas A. Plocher, Wei-Bin Zhang, Steven E. Shladover*

We identify possible multiple major failure events by assuming the failure of one operational function

at a time. We also define possible failure consequences and possible system responses to resolve the failure event. True human capability is a crucial subject for future investigation.

UCB-ITS-PWP-97-4

February 1997, 75 pp, \$15.00

#### **Models, Simulation, and Performance of Fully Automated Highways**

*Pravin Varaiya*

A brief reconstruction of the history of the AHS concept and a summary of the principal findings of AHS performance is followed by an overview of the simulation program SmartPath. An outline of the current work on SmartPath and plans for the immediate future are given.

UCB-ITS-PRR-94-21

October 1994, 18 pp, \$5.00

#### **Spacing and Capacity Evaluations for Different AHS Concepts**

*Alexander Kanaris, Petros Ioannou, Fu-Sheng Ho*

The trade-off between capacity and safety gives rise to a variety of different AHS concepts and architectures. In this study we consider a family of six AHS operational concepts. For each concept we calculate the minimum intervehicle spacing that could be used for collision-free vehicle following, under different road conditions.

UCB-ITS-PRR-96-30

November 1996, 62 pp, \$15.00

#### **Smart Cars on Smart Roads: Problems of Control**

*Pravin Varaiya*

Outlines key features of one highly automated IVHS system, shows how core driver decisions are improved, proposes a basic IVHS control system architecture, and offers a design of some control subsystems.

TECH MEMO-91-5

December 1991, 30 pp, \$5.00

#### **Staggered-Diamond Design for Automated/Manual-HOV Highway-to-Highway Interchange**

*H.-S. Jacob Tsao*

Proposes a staggered-diamond design requiring only four separate structures, each supporting two-way traffic, for the eight additional connector ramps for AHS that requires. Discusses the constraints of this design on the conceptual design and evolution of AHS. The proposed design increases the feasibility of a freeway shuttle van service, proposed by Tsao as the initial AHS deployment target.

UCB-ITS-PRR-95-31

September 1995, 31 pp, \$10.00

### **Time Benefits of New Transportation Technologies: The Case of Highway Automation**

*Randolph W. Hall*

Components of travel time are introduced and compared. A series of highway automation concepts is created, and the time benefits of each are discussed.

UCB-ITS-PWP-91-4

June 1991, 48 pp, \$7.00

### **Towards a Fault Tolerant AHS Design Part I: Extended Architecture**

*John Lygeros, Datta N. Godbole;*

*Mireille Broucke*

Proposes a hierarchical control architecture for dealing with faults and adverse environmental conditions on an Automated Highway System (AHS). A companion paper, UCB-ITS-PRR-96-15, develops and verifies protocols for extended coordination strategies and maneuvers.

UCB-ITS-PRR-96-14

June 1996, 47 pp, \$5.00

### **Traffic Control for Automated Highway Systems: A Conceptual Framework**

*H.-S. Jacob Tsao*

Since vehicle movement plans are generated by various controllers in the AHS, planned vehicle moves have the potential of conflicting and interfering with one another. This paper defines all permissible vehicle movements in terms of "building block" moves, then identifies and defines planning and movement functions required for supporting desired control features.

UCB-ITS-PRR-95-30

September 1995, 39 pp, \$10.00

### **AHS Modeling and Simulation**

#### **Modeling and Simulation of the Automated Highway System**

*Farokh H. Eskafi*

The SmartPath visual simulation package provides a graphical interface to view vehicle and highway data in a natural way. SmartPath is a micro-simulation: the behavior of each functional element of the vehicle and highway is individually modeled and simulated. SmartPath is also a distributed simulation, so that different sections of the highway network can be simulated in different processors.

UCB-ITS-PRR-96-19

July 1996, 112 pp, \$20.00

### **SHIFT Programming Language and Run-time System for Dynamic Networks of Hybrid Automata**

*Akash Deshpande, Aleks Göllü and Luigi Semenzato*

SHIFT is a programming language for describing dynamic networks of hybrid automata. It offers the proper level of abstraction for describing complex applications such as automated highway systems. The main features of the SHIFT language and the run-time environment for simulating SHIFT programs are described.

UCB-ITS-PRR-97-7

January 1997, 21 pp, \$5.00

### **SHIFT Reference Manual**

*Akash Deshpande, Aleks Göllü and Luigi Semenzato*

The SHIFT description language for dynamic networks of hybrid systems offers the proper level of abstraction for describing complex applications such as highway and air traffic control systems, robotic shopfloors, and other systems whose operation cannot be captured by conventional models. SHIFT supports the definition and enforcement of Automated Highway System Tool Interchange Format (AHSTIF) specific semantics.

UCB-ITS-PRR-97-8

January 1997, 15 pp, \$5.00

### **AHS Sensors**

#### **Intelligent Sensor Validation and Sensor Fusion for Reliability and Safety Enhancement in Vehicle Control**

*Alice Agogino, Kai Goebel, Satnam Alag*

An evaluation of methods for validation and fusion of sensor readings obtained from multiple sensors, to be used in tracking automated vehicles and avoidance of obstacles in a vehicle's path. Tests were conducted under dynamic and static test conditions, as well as under vibrations.

UCB-ITS-PRR-95-40

November 1995, 56 pp, \$15.00

### **AHS Traffic Management**

#### **AHSCAP Dynamic Traffic Assignment Program User's Manual and Design Description**

*Bruce Hongola*

AHSCAP is a computer model of automated highway system capacity and demand, operational characteristics, and defined infrastructure. The model features an analytic, flow-based optimization approach that involves solving a linear program.

UCB-ITS-PWP-96-7

June 1996, 25 pp, \$10.00

### **Vehicle Control Design for Infrastructure Managed Vehicle Following**

*H. Raza, P. Ioannou*

Design and test of a vehicle control system that achieves full vehicle automation in the longitudinal direction for several modes of operation, where the infrastructure manages vehicle following. These modes include autonomous vehicles, cooperative vehicle following, and platooning. Simulation and experimental results are included.

UCB-ITS-PRR-96-29

November 1996, 11 pp, \$10.00

### **Continuum Theory of Traffic Dynamics for Freeways with Special Lanes**

*Carlos F. Daganzo*

This mathematical formulation of traffic flow on freeways accommodating regular and special vehicles requires very few data, which are easy to obtain. The solution can be described completely by a set of diagrams.

Tech Note 95-8

December 1995, 35 pp, \$10.00

### **DYN-OPT Users Manual**

*Cenk Caliskan, Randolph W. Hall*

This document is a users manual for DYN-OPT, a linear program that optimally and dynamically assigns traffic to lanes on an automated highway. The program maximizes the total flow across the highway over a specified length of time.

UCB-ITS-PWP-97-6

February 1997, 19 pp, \$5.00

### **Dynamic Traffic Assignment for Automated Highway Systems: A Two-Lane Highway with Speed Constancy**

*Jacob Tsao*

Identifies a general class of equations/inequalities to represent the impact of lane changes and merges on AHS longitudinal flow and develops mathematical models for system-optimal dynamic traffic assignment on a two-lane (one-direction) automated highway.

UCB-ITS-PWP-96-12

August 1996, 33 pp, \$10.00

### **Inter-Vehicle Spacing: User's Manual**

*Petros Ioannou, Alexander Kanaris, Alex Grammagnat*

The Inter-Vehicle Spacing software tool (IVS) provides a user friendly interactive interface that allows you to calculate minimum initial spacings between two vehicles, calculate the possibility and severity of collision between two vehicles, visualize

motion during braking maneuvers, and calculate highway capacity.

UCB-ITS-PWP-97-10

March 1997, 22 pp, \$5.00

### **LANE-OPT Users Manual Version 1.0**

*David Lotspeich, Randolph W. Hall*  
User manual for LANE-OPT, a linear-program based software package that optimally assigns traffic to lanes on an automated highway.

UCB-ITS-PWP-96-2

March 1996, 22 pp, \$5.00

### **Optimized Lane Assignment on an Automated Highway**

*Randolph W. Hall, David Lotspeich*

Develops and applies a linear-programming based model for assigning traffic to lanes on an automated highway system. The highway is modeled as a multi-commodity network, where the commodities are differentiated by trip destinations.

UCB-ITS-PWP-96-3

March 1996, 42 pp, \$10.00

### **Safety and Efficiency Tradeoff Analysis for Automated Highway System: Part 3: Longitudinal Separation on AHS: A Trade-off between Collision Probability/Severity and Capacity**

*H.-S. Jacob Tsao, Randolph W. Hall*

Develops a probabilistic model for analyzing longitudinal collision/safety between an abruptly decelerating vehicle and its immediate follower on an Automated Highway System. This model has many other applications.

UCB-ITS-PWP-97-8

February 1997, 21 pp, \$10.00

### **Theory of Traffic Flow in Automated Highway Systems**

*Mireille Broucke, Pravin Varaiya*

Our theory is based on an abstraction of vehicle activities like entry, exit, and cruising, derived from a vehicle's automatic control laws. An activity is represented in the flow model by the space occupied by a vehicle engaged in that activity. The theory formulates TMC traffic plans as the specification of the activities and speed of vehicles, and the entry and exit flows for each highway section.

UCB-ITS-PRR-95-43

December 1995, 32 pp, \$10.00

### **Coordination and Link Layer Control**

#### **AVHS Link Layer Controller for Traffic Flow Stabilization**

*Perry Li, Roberto Horowitz, Luis Alvarez,*

*Jonathan Frankel, Anne M. Robertson*

Controls for the link layer in the AVHS hierarchy proposed in PATH

are developed. The control laws obtained are suited for implementation in the lower levels of the AVHS control hierarchy. Simulation results are also presented.

Tech Note 95-7  
November 1995, 43 pp, \$15.00

#### **Design of Platoon Maneuver Protocols for IVHS**

*Ann Hsu, Farokh Eskafi, Sonia Sachs, Pravin Varaiya*

We consider the design of the controllers for platoons of up to twenty closely spaced vehicles under automatic control.

UCB-ITS-PRR-91-6  
April 1991, 60 pp, \$7.00

#### **Macroscopic Roadway Traffic Controller Design**

*C.C. Chien, Y. Zhang, A. Stotsky, S.R. Dharmasena, P. Ioannou*

A roadway controller is designed, analyzed and simulated for a single automated highway lane that achieves desired traffic densities along the lane. Simulation results are used to illustrate the controller's effectiveness and the significant benefits AHS may bring to traffic flow.

UCB-ITS-PRR-95-28  
August 1995, 29 pp, \$10.00

#### **Hierarchical Hybrid Control of Automated Highway Systems**

*Dattaprabodh Narhar Godbole*

Describes individual layers of the hierarchical control architecture for platooning, the design of a regulation layer feedback controller for platoon leaders, an interface between this feedback controller and the discrete event coordination layer, and an analysis of the combined hybrid system using a dedicated simulation tool.

UCB-ITS-PRR-95-8  
March 1995, 147 pp, \$20.00

#### **Robust Platoon Maneuvers for AVHS**

*Jonathan Frankel, Luis Alvarez, Roberto Horowitz, Perry Li*

Presents new control strategies for the three longitudinal maneuvers: merge, split and decelerate to change lanes. A merge maneuver in which the velocity of the trail platoon never exceeds the maximum safe velocity is examined, and the control approach is applied to the other maneuvers.

Tech Note 94-9  
November 1994, 37 pp, \$7.00

#### **Towards a Fault Tolerant AHS Design Part I: Extended Architecture**

*John Lygeros, Datta N. Godbole, Mireille Broucke*

Proposes a hierarchical control architecture for dealing with faults and adverse environmental conditions on an Automated Highway System (AHS). A companion paper, abstracted in UCB-ITS-PRR-96-15, develops and verifies protocols for extended coordination strategies and maneuvers.

UCB-ITS-PRR-96-14  
June 1996, 47 pp, \$5.00

#### **Towards a Fault Tolerant AHS Design Part II: Design and Verification of Communication Protocols**

*D.N. Godbole, J. Lygeros, E. Singh, A. Deshpande, A.E. Lindsey*

Presents the design and verification of intervehicle communication protocols for degraded modes of operation on an Automated Highway System (AHS). Considers hardware and sensor faults that might develop on an automated vehicle, and designs supervisory controllers to stop a faulty vehicle or take it off the highway.

UCB-ITS-PRR-96-15  
June 1996, 41 pp, \$10.00

#### **Two Proposals to Improve Freeway Traffic Flow**

*Ufuk Karaaslan, Pravin Varaiya, Jean Walrand*

A plausible model of platoons in which the lead car is manually driven indicates that for an average platoon size of 10, freeway capacity increases by a factor of four.

UCB-ITS-PRR-90-6  
April 1990, 22 pp, \$5.00

#### **Fault Detection and Vehicle Control**

#### **Fault Detection and Identification with Application to Advanced Vehicle Control Systems: Final Report**

*Randal K. Douglas, Jason L. Speyer, D. Lewis Mingori, Robert H. Chen, Durga P. Malladi, Walter H. Chung*

Describes a system that monitors twelve sensors and three actuators to assess the "health" of the control system. The approach is to fuse data from dissimilar instruments using modeled dynamic relationships, as well as fault detection and identification filters.

UCB-ITS-PRR-96-25  
September 1996, 301 pp, \$40.00

#### **Hybrid System Modeling and Control**

#### **Hierarchical, Hybrid Control of Large Scale Systems**

*John Lygeros*

Our analysis is based on a new hybrid dynamical system formulation that allows us to model large scale systems in a modular fashion. Three problems are addressed: controller design, closed loop performance verification, and the extension of system autonomy. A case study on the application of the proposed techniques to the control of an automated highway system is presented.

UCB-ITS-PRR-96-23  
September 1996, 57 pp, \$30.00

#### **SHIFT Programming Language and Run-time System for Dynamic Networks of Hybrid Automata**

*Akash Deshpande, Aleks Göllü, Luigi Semenzato*

SHIFT is a programming language for describing dynamic networks of hybrid automata. It offers the proper level of abstraction for describing complex applications such as automated highway systems. The main features of the SHIFT language and the run-time environment for simulating SHIFT programs are described.

UCB-ITS-PRR-97-7  
January 1997, 21 pp, \$5.00

#### **SHIFT Reference Manual**

*Akash Deshpande, Aleks Göllü, Luigi Semenzato*

The SHIFT description language for dynamic networks of hybrid systems offers the proper level of abstraction for describing complex applications such as highway and air traffic control systems, robotic shopfloors, and other systems whose operation cannot be captured by conventional models. SHIFT supports the definition and enforcement of Automated Highway System Tool Interchange Format (AHSTIF) specific semantics.

UCB-ITS-PRR-97-8  
January 1997, 15 pp, \$5.00

#### **Towards a Fault Tolerant AHS Design Part II: Design and Verification of Communication Protocols**

*D.N. Godbole, J. Lygeros, E. Singh, A. Deshpande, A.E. Lindsey*

Presents the design and verification of intervehicle communication protocols for degraded modes of operation on an Automated Highway System (AHS). Considers hardware and sensor faults that might develop on an automated vehicle, and de-

signs supervisory controllers to stop a faulty vehicle or take it off the highway.

June 1996, 41 pp, \$10.00

#### **Verified Hybrid Controller for Automated Vehicles**

*John Lygeros, Datta N. Godbole, Shankar Sastry*

Here we apply game theoretic design techniques developed to design hybrid controllers that guarantee safe and efficient operation, eliminating the need for verification. The final theorems are specialized to the platooning concept, but the details of the calculations are general enough to apply to any vehicle control problem.

UCB-ITS-PRR-97-9  
February 1997, 60 pp, \$15.00

#### **Integrated Lateral and Longitudinal Control**

#### **Combined Longitudinal and Lateral Control of a Platoon of Vehicles: A System Level Study**

*Shahab Sheikholeslam, Charles A. Desoer*

The authors propose nonlinear control laws for a platoon of non-identical vehicles accelerating on a curved lane of highway. These laws are based on nonlinear models of vehicles' combined longitudinal and lateral dynamics.

TECH MEMO-91-3  
September 1991, 28 pp, \$5.00

#### **Fuzzy Throttle and Brake Control for Platoons of Smart Cars**

*Hyun Mun Kim, Julie Dickerson, Bart Kosko*

The authors designed and tested a throttle-only fuzzy system on a validated car model and then with a real car on highway I-15 in California. They then designed a throttle and brake controller.

UCB-ITS-PRR-95-42  
December 1995, 46 pp, \$10.00

#### **Integrated Maneuvering Control for Automated Highway Systems Based on a Magnetic Reference Sensing System**

*Masoyoshi Tomizuka, J. Karl Hedrick, Hung Pham*

A model of a combined longitudinal and lateral eighteen-state vehicle chassis, engine, and drive train is developed and validated against existing longitudinal-only and lateral-only vehicle models. The full-size model is simplified to a three-state model to facilitate controller design.

UCB-ITS-PRR-95-12  
April 1995, 57 pp, \$15.00



## ■ Lateral Control

### Adaptation Method for Fuzzy Logic Controllers in Lateral Vehicle Guidance

*Thomas Hessburg, Masayoshi Tomizuka*  
A formulation is made for a model reference adaptive fuzzy logic control (MRAFLC) algorithm and applied to automatic steering control of a vehicle. The purpose is to design a fuzzy logic controller that addresses changes in operating conditions, including vehicle speed and road surface conditions, in the controller. UCB-ITS-PRR-95-21  
June 1995, 50 pp, \$10.00

### Advances in Fuzzy Logic Control for Lateral Vehicle Guidance

*Thomas Hessburg, Masayoshi Tomizuka*  
The most recent fuzzy logic controller (FLC), with a rule base derived from heuristics, is a good choice for lateral guidance in lane following, where the objective is to track the center of a lane with smooth ride quality under a range of varying operating conditions such as vehicle speed, wind gusts, and road conditions. UCB-ITS-PWP-94-4  
March 1994, 29 pp, \$5.00

### Analysis of Automatic Steering Control for Highway Vehicles with Look-down Lateral Reference Systems

*Jürgen Guldner, Han-Shue Tan, Satyajit Patwardhan*  
Examines issues of steering control for passenger cars on automated highways. Extending earlier low speed experimental results to highway speed is shown to be nontrivial. The limitations of pure output-feedback of lateral vehicle displacement from the road reference are examined under practical constraints and such performance requirements as robustness, maximum lateral error and comfort. Tech Note 96-3  
April 1996, 24 pp, \$5.00

### Experimental Automatic Lateral Control System for an Automobile

*Heui Peng, Wei-Bin Zhang, Alan Arai, Ye Lin, Thomas Hessburg, Peter Devlin, Masayoshi Tomizuka, Steven Shladover*  
The project included a discrete roadway reference system, on-vehicle magnetic sensing system, a computer control system, and a hydraulic actuator. UCB-ITS-PRR-92-11  
November 1992, 148 pp, \$16.00

### Experimental Results of Fuzzy Logic Control for Lateral Vehicle Guidance

*Thomas Hessburg, Huei Peng, Wei-Bin Zhang, Alan Arai, Masayoshi Tomizuka*  
A fuzzy logic controller (FLC) is designed and implemented in real time on a Toyota Celica test vehicle, automatically following a multiple curved track using discrete magnetic markers as a lateral error reference system. Results are compared to tests using the frequency shaped linear quadratic (FSLQ) controller with preview control. UCB-ITS-PRR-94-3  
February 1994, 5 pp, \$7.00

### Experimental Study of Chatter Free Sliding Mode Control for Lateral Control of Commuter Buses in AHS

*Pushkar Hingwe, Masayoshi Tomizuka*  
Passenger load uncertainties and variations in road-tire interaction in commuter buses require a nonlinear control strategy to take care of variation in longitudinal velocity. Two Sliding Mode Control (SMC) based controllers were designed. One was chosen for experimental verification because it guarantees asymptotic tracking with no chatter in the control input to the steering actuator of the vehicle. UCB-ITS-PRR-96-31  
November 1996, 26 pp, \$10.00

### Experimental Study on Lateral Control of a Vehicle

*Thomas Hessburg, Huei Peng, Masayoshi Tomizuka, Wei-Bin Zhang*  
Results demonstrate the feasibility of proposed discrete magnetic marker reference/sensing system. Performance and limitations of a PID/feed-forward controller are also investigated. UCB-ITS-PRR-91-17  
August 1991, 13 pp, \$5.00

### Fault Detection and Tolerant Control for Lateral Guidance of Vehicles in Automated Highways

*Satyajit Neelkanth Patwardhan*  
The main problems addressed are tire burst, sensor fault detection, and slip angle control. Tire burst and sensor faults are important failure modes for automated highways, whereas the slip angle control problem is important during maneuvers to enhance vehicle safety. UCB-ITS-PRR-94-17  
August 1994, 130 pp, \$15.00

### Feasibility Study of Advanced Technology HOV Systems. Volume 4: Implementation of Lateral Control Systems in Transitways

*T. Chira-Chavala, W-B. Zhang, J. Walker, F. Javanel, L. Demsetz*  
Incremental systems for implementation in existing transitways, potential safety and capacity impacts of these systems, and human-factor issues relevant for the implementation of these systems. UCB-ITS-PRR-92-6  
December 1992, 56 pp, \$7.00

### Fuzzy Logic Control for Lane Change Maneuvers in Lateral Vehicle Guidance

*Thomas Hessburg, Masayoshi Tomizuka*  
Investigates the feasibility of a fuzzy logic control algorithm for lateral control in a maneuver that takes a vehicle from lane following control in one lane to lane following control in an adjacent lane. The only sensor used for feedback is a lateral accelerometer. UCB-ITS-PWP-95-13  
October 1995, 11 pp, \$5.00

### Fuzzy Rule-Based Controller for Automotive Vehicle Guidance

*Thomas Hessburg, Masayoshi Tomizuka*  
Fuzzy rules, based on human drivers' experiences, are developed to track the center of a lane in the presence of external disturbances and over a range of vehicle operating conditions. UCB-ITS-PRR-91-18  
August 1991, 20 pp, \$5.00

### Integrated Maneuvering Control Design and Experiments: Phase II

*J.K. Hedrick, M. Pantarotto, T. Yoshioka, Y-H Chen, T. Connolly, V.K. Narendran*  
Examines autonomous lateral vehicle control, with sections on Cooperative Intelligent Cruise Control (CICC) and the effect of communication delays on the control performance of vehicle platoons. Studies the three basic Automated Highway System transition maneuvers: join, split, and lane change. UCB-ITS-PRR-96-2  
January 1996, 176 pp, \$25.00

### Lateral Control of Front-Wheel-Steering Rubber-Tire Vehicles

*Huei Peng, Masayoshi Tomizuka*  
The performance of lateral feedback and feed-forward controllers is evaluated on a complex model, which includes motions in all six directions (longitudinal, lateral, vertical, roll, pitch, and yaw). UCB-ITS-PRR-90-5  
July 1990, 45 pp, \$7.00

### Lateral Control of Tractor-Semitrailer Vehicles in Automated Highway Systems

*Chieh Chen, Masayoshi Tomizuka*  
Linear quadratic optimal control with and without frequency shaping is utilized to design a steering controller for tractor-semitrailer vehicles in Automated Highway Systems (AHS). To enhance driving safety, we propose to use independent braking forces in the trailer as another control input. UCB-ITS-PRR-96-33  
November 1996, 29 pp, \$10.00

### Lateral Guidance Systems Requirements Definition

*Robert E. Parsons, Wei-Bin Zhang*  
Presents a definition of PATH lateral guidance system requirements, followed by a discussion of different sensor systems (reference, passive reference, radar and acoustic). UCB-ITS-PRR-88-1  
August 1988, 18 pp, \$5.00

### Machine Vision Based System for Guiding Lane-Change Maneuvers. Final Report

*Jitendra Malik, Dieter Koller, Tuan Luong*  
A new approach for vision based longitudinal and lateral vehicle control making extensive use of binocular stereopsis. A known camera geometry with respect to the locally planar road is used to map images of the road plane in two camera views into alignment. A disparity then indicates an object not lying in the road plane and hence a potential obstacle. UCB-ITS-PRR-95-34  
October 1995, 47 pp, \$10.00

### Optimal Preview Control for Vehicle Lateral Guidance

*Huei Peng, Masayoshi Tomizuka*  
The continuous time deterministic optimal preview control algorithm is applied to lateral guidance of a vehicle for an automated highway. UCB-ITS-PRR-91-16  
August 1991, 27 pp, \$5.00

### Theoretical and Empirical Analysis of PATH Magnetic Lane Tracking for the Intelligent Vehicle Highway System

*Angus Andrews, Rockwell International Science Center*  
Characterizes statistical performance of the magnetic nails concept for estimating the positions of vehicles within their marked lanes. Presents a mathematical model for sensor noise due to distortions of the earth's field by patterns of ferrous reinforcing bars in the pavement. UCB-ITS-PRR-92-9  
August 1992, 94 pp, \$11.00

### **Vehicle Lane Change Maneuver in Automated Highway Systems**

*Wonshik Chee, Masayoshi Tomizuka*  
Lane change maneuvers for an AHS are investigated as a tracking problem with respect to the virtual desired trajectory (VDT). The two main issues discussed are: 1) design of virtual desired trajectory and 2) design of control algorithms.  
UCB-ITS-PRR-94-22  
October 1994, 37 pp, \$7.00

### **Longitudinal Control**

#### **Adaptive Vehicle Traction Control**

*Hyeongcheol Lee, Masayoshi Tomizuka*  
Presents two different control algorithms for adaptive vehicle traction control, which includes wheel slip control, optimal time control, anti-spin acceleration and anti-skid control, and longitudinal platoon control. The two control algorithms are based, respectively, on adaptive fuzzy logic control and sliding mode control, with on-line road condition estimation.  
UCB-ITS-PRR-95-32  
September 1995, 73 pp, \$15.00

#### **Analysis, Design, and Evaluation of AVCS for Heavy-Duty Vehicles**

*Diana Yanakiev, Ioannis Kanellakopoulos*  
Develops two new nonlinear spacing policies—variable time headway and variable separation error gain—that all but eliminate the large steady-state intervehicle spacings characteristic of heavy-duty vehicles. The first policy allows us to use much smaller spacings in autonomous platoon operation; the second results in smoother and more robust longitudinal control.  
UCB-ITS-PRR-96-26  
September 1996, 39 pp, \$10.00

#### **Brake Dynamics Effect on IVHS Lane Capacity**

*Dragos B. Maciuca*  
An assessment of the effects of brake system dynamics and intervehicle communication delays (microscopic characteristics) on the capacity of an automated highway system (macroscopic characteristics). Recommendations are made about maximum desired delays, intraplatoon and interplatoon distances, and platoon size.  
UCB-ITS-PWP-94-16  
October 1994, 24 pp, \$7.00

### **Coding of Road Information for Automated Highways**

*Jürgen Guldner, Satyajit Patwardhan, Han-Shue Tan, Wei-Bin Zhang*  
Information coding in the lateral reference used for automatic steering and lane keeping control, e.g., in the PATH magnet reference system, presents a suitable channel for communication of information from the roadway infrastructure to vehicles. Types and structure of coded information, encoding and decoding schemes, and possible future extensions are discussed.  
UCB-ITS-PWP-97-7  
February 1997, 19 pp, \$5.00

### **Feasibility Study of Advanced Technology HOV Systems. Volume I: Phased Implementation of Longitudinal Control Systems**

*T. Chira-Chavala, S.M. Yoo*  
The study is divided into 5 volumes. Vol. 1 identifies strategies for early deployment of this technology.  
UCB-ITS-PRR-92-2  
December 1992, 111 pp, \$11.00

### **Fuzzy Logic Traction Controllers and Their Effect on Longitudinal Vehicle Platoon Systems**

*M. Bauer, Masayoshi Tomizuka*  
A fuzzy logic approach is appealing for traction control because of the non-linearities and time-varying uncertainties in traction control systems. One fuzzy controller estimates the “peak slip” corresponding to the maximum tire-road adhesion coefficient and regulates wheel slip at that value. Another regulates wheel slip at any desired value.  
UCB-ITS-PRR-95-14  
May 1995, 39 pp, \$10.00

### **Fuzzy Traffic Density Homogenizer for Automated Highway Systems**

*C.C. Chien, P. Ioannou, C.K. Chu*  
Proposes a fuzzy traffic density homogenizer to alleviate or avoid congestion by soothing the traffic density distribution profile over the freeway lanes.  
UCB-ITS-PRR-95-44  
December 1995, 20 pp, \$10.00

### **Handbook for Intervehicle Spacing in Vehicle Following**

*Y. Sun, P. Ioannou*  
A general worst-case stopping scenario for vehicle following is used to develop algorithms for generating the minimum safety spacing (MSS) for collision-free vehicle following. These algorithms are used to study the effects of vehicle characteristics and other parameters on the value of the MSS.  
UCB-ITS-PRR-95-1  
January 1995, 41 pp, \$7.00

### **Integrated Maneuvering Control Design and Experiments: Phase 1**

*J. Karl Hedrick, Pravin Varaiya, V.K. Narendran, Sei-Bum Choi*  
Addresses the issues of vehicle control during transition maneuvers in Intelligent Vehicle Highway Systems. Transition maneuvers include automatic lane change of vehicles and merging and splitting of platoons of vehicles in the automated highway system. Also addresses issues involved in implementation of longitudinal control laws for vehicle control.  
UCB-ITS-PRR-95-15  
May 1995, 66 pp, \$15.00

### **Inter-Vehicle Spacing: User's Manual**

*Petros Ioannou, Alexander Kanaris, Alex Grammatagis*  
The Inter-Vehicle Spacing software tool (IVS) provides a user friendly interactive interface that allows you to calculate minimum initial spacings between two vehicles, calculate the possibility and severity of collision between two vehicles, visualize motion during braking maneuvers, and calculate highway capacity.  
UCB-ITS-PWP-97-10  
March 1997, 22 pp, \$5.00

### **Longitudinal Control - Phase 1**

*Kwang Soo Chang*  
Assesses the feasibility of vehicle-follower control using a Doppler radar as the primary sensor. The collision warning test program and system characterization test program are discussed, followed by a description of an experimental setup for vehicle-following tests. Results of two-car and four-car experiments are reported, followed by conclusions.  
UCB-ITS-PRR-95-22  
August 1995, 105 pp, \$10.00

### **Longitudinal Control Development for IVHS Fully Automated and Semi-Automated Systems - Phase I**

*J. Karl Hedrick, D.H. McMahon, D. Swaroop, V. Garg, J.C. Gerdes, D.B. Maciuca, T.T. Blackman, P.P. Yip*  
Addresses some of the important longitudinal vehicle modeling and control issues of AVCS, such as brake dynamic model development and validation, decentralized longitudinal control algorithms that guarantee the stability of the entire platoon, and fault detection and isolation in the longitudinal vehicle dynamics of controlled vehicles.  
UCB-ITS-PRR-95-4  
January 1995, 128 pp, \$14.00

### **Longitudinal Control Development for IVHS Fully Automated and Semi-Automated Systems: Phase II**

*J.K. Hedrick, J.C. Gerdes, D.B. Maciuca, D. Swaroop, V. Garg*  
Addresses the braking controller design issues, effects of braking on IVHS lane capacity, performance of platoons with various information structures, and fault detection filter design for automated vehicle control systems. (AVCS).  
UCB-ITS-PRR-96-1  
January 1996, 126 pp, \$20.00

### **Longitudinal State Estimation for a Four-Vehicle Platoon**

*A.W. Merz*  
Dynamic equations and data are used for finding the estimates and root means squared errors in the estimated of the states for each vehicle. Several additional parameters require numerical specification, including data and process noise levels.  
UCB-ITS-PRR-95-27  
August 1995, 63 pp, \$15.00

### **Longitudinal Control - Phase 1**

*Kwang Soo Chang*  
Assesses the feasibility of vehicle-follower control, though traffic platoon control, with high accuracy and good ride quality, using a Doppler radar as the primary sensor.  
UCB-ITS-PRR-95-22  
August 1995, 105 pp, \$20.00

### **Longitudinal Control of the Lead Car of a Platoon**

*Datta Godbole, John Lygeros*  
Schemes that maintain safe spacing, track an optimal velocity and perform various maneuvers (forming, breaking up platoons and changing lanes) are described.  
TECH MEMO-93-7  
November 1993, 31 pp, \$7.00

### **Longitudinal Control of a Platoon of Vehicles I: Linear Model**

*Shahab Sheikholeslam, Charles A. Desoer*  
A systematic analysis of a longitudinal control law of a platoon of vehicles using a linear model to represent the vehicle dynamics of each vehicle within the platoon.  
UCB-ITS-PRR-89-3  
August 1989, 29 pp, \$5.00

### **Longitudinal Control of a Platoon of Vehicles II: First and Second Order Time Derivatives of Distance Deviations**

*Shahab Sheikholeslam, Charles A. Desoer*  
Establishes the benefit resulting from having both first- and second-order



time derivatives of distance deviations available.  
UCB-ITS-PRR-89-6  
August 1989, 23 pp, \$5.00

**Longitudinal Control of a Platoon of Vehicles III: Nonlinear Model**  
*Shahab Sheikholeslam, Charles A. Desoer*

A control law is developed and is tested on a simulation of a platoon of 16 vehicles.  
UCB-ITS-PRR-90-1  
April 1990, 24 pp, \$5.00

**Longitudinal Control of a Platoon of Vehicles with No Communication of Lead Vehicle Information: A System Level Study**  
*Shahab Sheikholeslam, Charles A. Desoer*

In case of loss of communication between the lead vehicle and the other vehicles, the performance of the longitudinal control laws degrades; but this degradation is not catastrophic.  
TECH MEMO-91-2  
August 1991, 23 pp, \$5.00

**Longitudinal Model Development for Automated Roadway Vehicles**  
*Donn H. McMahon, J. Karl Hedrick*  
Describes model development for longitudinal analysis and the longitudinal model simulation package, LONSIM. The results of simulations using the power-train model are given.  
UCB-ITS-PRR-89-5  
October 1989, 67 pp, \$7.00

**Modeling and Control Design for a Computer Controlled Brake System**  
*H. Rasa, Z. Xu, P. Ioannou, B. Yang*  
Simulation results show that the proposed controller guarantees no overshoot and zero steady state error for step inputs. Tests of the controller using an experimental bench setup demonstrates its effectiveness in meeting the performance requirements.  
UCB-ITS-PRR-95-37  
November 1995, \$10.00

**Modeling of the Brake Line Pressure to Tire Brake Force**  
*T. Xu, P. Ioannou*

Experimental data from a series of tests performed in collaboration with Ford research engineers are used to model the brake line pressure to tire brake force subsystem.  
UCB-ITS-PWP-94-6  
April 1994, 71 pp, \$8.00

**Safety and Efficiency Tradeoff Analysis for Automated Highway System: Part 3: Longitudinal Separation on AHS: A Trade-off between Collision Probability/Severity and Capacity**  
*H.-S. Jacob Tsao, Randolph W. Hall*  
Develops a probabilistic model for analyzing longitudinal collision/safety between an abruptly decelerating vehicle and its immediate follower on an Automated Highway System. This model has many other applications.  
UCB-ITS-PWP-97-8  
February 1997, 21 pp

**Throttle and Brake Control Systems for Automatic Vehicle Following**  
*P. Ioannou, Z. Xu*  
Control systems are designed and tested first using a validated nonlinear vehicle model and then in actual vehicles. Stability is guaranteed by using a constant time headway policy and designing the control system to apply throttle and brake appropriately.  
UCB-ITS-PRR-94-10  
April 1994, 34 pp, \$7.00

**Time Headway Autonomous Intelligent Cruise Controller: Design and Simulations**  
*P.A. Ioannou, F. Ahmed-Zaid, D.H. Wuh*  
This scheme maintains a steady state inter-vehicle spacing decided by a desired time headway set by the driver. The longitudinal model of the Lincoln Towncar is used for simulations and testing.  
UCB-ITS-PWP-94-7  
April 1994, 31 pp, \$7.00

**Transitional Platoon Maneuvers in an Automated Highway System**  
*J.K. Hedrick, V.K. Narendran, K.-S. Chang*  
An introduction to the control aspect of platoon maneuvers in AHS. The survey is split up into the quasi-synchronous and vehicle follower controller methods of approach.  
UCB-ITS-PRR-92-16  
December 1992, 30 pp, \$7.00

**Vehicle Control Design for Infrastructure Managed Vehicle Following**  
*H. Raza, P. Ioannou*  
Design and test of a vehicle control system that achieves full vehicle automation in the longitudinal direction for several modes of operation, where the infrastructure manages vehicle following. These modes include autonomous vehicles, cooperative vehicle following and platooning. Simulation and experimental results are included.  
UCB-ITS-PRR-96-29  
November 1996, 11 pp, \$10.00

**Vehicle Following Control Design for Automated Highway Systems**  
*H. Raza, P. Ioannou*  
Covers the design and testing of a vehicle control system for full vehicle automation in the longitudinal direction for several modes of operation, where the infrastructure manages the following vehicle. These modes include autonomous vehicles, cooperative vehicle following and platooning.  
UCB-ITS-PRR-97-2  
January 1997, 54 pp, \$15.00

**Vehicle Longitudinal Control Test**  
*Sei-Bum Choi*  
Evaluates several engine torque control laws for longitudinal vehicle control. The control laws are implemented and tested on a low speed test track. The test results and analysis show that engine manifold air dynamics cannot be neglected, especially at low engine speed.  
UCB-ITS-PWP-94-15  
October 1994, 23 pp, \$7.00

**Vehicle Longitudinal Control Using Discrete Markers**  
*David W. Love, Masayoshi Tomizuka*  
Develops a hybrid observer as a method of estimating position and velocity of a vehicle when the primary input is a series of discrete magnetic markers. A Proportional-Integral-Derivative (PID) controller acting on error signals from the hybrid observer is also developed and simulated.  
UCB-ITS-PRR-94-28  
December 1994, \$7.00

**Vehicle Modeling Control AHS**  
*J.K. Hedrick, D.H. McMahon, D. Swaroop*  
Simulation results on multiple vehicle platoons demonstrate excellent tracking using spacing-based controllers. The use of headway-based controllers produced degraded performance as compared to the spacing-based controllers.  
UCB-ITS-PRR-93-24  
November 1993, 72 pp, \$9.00

**Vehicle Traction Control and its Applications**  
*Pushkin Kachroo, Masayoshi Tomizuka*  
Discusses vehicle traction control and its importance in highway automation. Shows that the system under traction control is stable in the presence of external disturbances, whereas the system under passive control may become unstable in the presence of external disturbances.  
UCB-ITS-PRR-94-8  
March 1994, 41 pp, \$7.00

**Platoon System Behavior**

**Aerodynamic Performance of Platoons: Final Report**  
*Michael Zabat, Nick Stabile, Stefano Frascaroli, Frederick Browand*  
The primary purpose of the tests described here is to quantify the behavior of vehicle drag as a function of vehicle spacing. Results show a reduction in average drag for all platoon members as a function of both intervehicle spacing and the number of vehicles in the platoon.  
UCB-ITS-PRR-95-35  
October 1995, 176 pp, \$25.00

**Design, Fabrication and Calibration of a Vehicle Tow Bar for Platoon Drag Measurements: A Working Report**  
*P. Hong, F. Browand, B. Marcu*  
A longitudinal stability model for a two-vehicle platoon yields a pair of linearly coupled equations that model the dynamics of the tow bar and the vehicles. Using reasonable approximations, the vehicle separation distance obeys a second order nonlinear differential equation with constant coefficients.  
UCB-ITS-PWP-97-2  
February 1997, 47 pp, \$10.00

**Drag Measurements on a Platoon of Vehicles: A Preliminary Report**  
*Michael Zabat, Stefano Frascaroli, Frederic Browand*  
Details the design and implementation of wind tunnel tests to evaluate the aerodynamic performance of individual members of 2, 3, and 4-vehicle platoons.  
UCB-ITS-PRR-93-27  
February 1994, 74 pp, \$16.00

**Low Speed Collision Dynamics and Control: Year One Report**  
*Benson H. Tongue, Ahrie Moon*  
Discusses issues investigated in the first phase of developing a simulation program to study platoon dynamics in both nominal and emergency scenarios. Preliminary issues include collision detection between the vehicles within the platoon and determining the platoon's post-crash behavior.  
UCB-ITS-PRR-95-25  
August 1995, 22 pp, \$5.00

**Platoon Collision Dynamics and Emergency Maneuvering I: Reduced Order Modeling of a Platoon for Dynamical Analysis**  
*B. Tongue, Y.-T. Yang, M. White*  
Preliminary results have shown that the reduced order model provides an accurate response match with the original model at a substantial computational savings.  
UCB-ITS-PRR-91-15  
August 1991, 59 pp, \$7.00

**Platoon Collision Dynamics and Emergency Maneuvering II: Platoon Simulations for Small Disturbances**

*Benson H. Tongue, Yean-Tzong Yang*  
Investigates the effect of selected parameter variations on the response of a platoon, also the response of a platoon under different control algorithms.  
UCB-ITS-PRR-94-4  
February 1994, 53 pp, \$7.00

**Platoon Collision Dynamics and Emergency Maneuvering III: Platoon Collision Models and Simulations**

*Benson Tongue, Yean-Tzong Yang*  
The platoon collision model is used to examine the effect, under four different control algorithms, of non-nominal operating conditions.  
UCB-ITS-PRR-94-2  
February 1994, 53 pp, \$7.00

**Platoon Collision Dynamics and Emergency Maneuvering IV: Intraplatoon Collision Behavior and A New Control Approach for Platoon Operation During Vehicle Exit/Entry - Final Report**

*Benson H. Tongue, Yean-Tzong Yang*  
Examines platoon behavior during non-nominal operations, especially emergency braking.  
UCB-ITS-PRR-94-25  
November 1994, 70 pp, \$9.00

**Qualitative Analysis on the Performance of Non-uniform Platoons: Report I, Non-Uniformities and Performance Issues**

*Benson H. Tongue, Andy Packard, Paul Sachi*  
Parameter uncertainty ranges were determined for a given model and for expected disturbances affecting its behavior in a platoon. Relevant criteria for determining platoon performance were then investigated, and a simulation code was written to evaluate platoon performance for a variety of scenarios.  
UCB-ITS-PRR-97-1  
January 1997, 15 pp, \$10.00

**Vehicle Designs and Experiments**

**Analysis, Design, and Evaluation of AVCS for Heavy-Duty Vehicles**

*Diana Yanakiev, Ioannis Kanellakopoulos*  
Develops two new nonlinear spacing policies—variable time headway and variable separation error gain—that all but eliminate the large steady-state intervehicle spacings characteristic of heavy-duty vehicles. The first policy allows us to use much smaller spacings in autonomous platoon

operation; the second results in smoother and more robust longitudinal control.  
UCB-ITS-PRR-96-26  
September 1996, 39 pp, \$10.00

**Brake System Analysis, Reliability Testing and Control Using Bench Experiments**

*Z. Xu, B. Yang*  
Investigates the dynamics and reliability of a brake control system using a test bench, which is a Lincoln Town Car brake system specifically designed by Ford. Project objectives were to experimentally characterize the system, obtain good nonlinear models of it, analyze its reliability, and develop algorithms for malfunction detection and reliability enhancement.  
UCB-ITS-PRR-97-10  
February 1997, 109 pp, \$10.00

**Design, Fabrication and Calibration of a Vehicle Tow Bar for Platoon Drag Measurements: A Working Report**

*P. Hong, F. Browand, B. Marcu*  
A longitudinal stability model for a two-vehicle platoon yields a pair of linearly coupled equations that model the dynamics of the tow bar and the vehicles. Using reasonable approximations, the vehicle separation distance obeys a second order nonlinear differential equation with constant coefficients.  
UCB-ITS-PWP-97-2  
February 1997, 47 pp, \$10.00

**Design, Modeling, and Control of Steering and Braking for an Urban Electric Vehicle**

*Dragos Maciuc*  
Results of an exchange with Programme Praxitèle of the Institut National de Recherche en Informatique et en Automatique (INRIA) in Rocquencourt, France, which provides people with self-service access to small electric cars. Control algorithms were developed for four-wheel steering and braking.  
UCB-ITS-PWP-96-11  
August 1996, 35 pp, \$10.00

**Experimental Study of Chatter Free Sliding Mode Control for Lateral Control of Commuter Buses in AHS**

*Pushkar Hingwe, Masayoshi Tomizuka*  
Passenger load uncertainties and variations in road-tire interaction in commuter buses require a nonlinear control strategy to take care of variation in longitudinal velocity. Two Sliding Mode Control (SMC) based controllers were designed. One was chosen for experimental verification

because it guarantees asymptotic tracking with no chatter in the control input to the steering actuator of the vehicle.  
UCB-ITS-PRR-96-31  
November 1996, 26 pp, \$10.00

**Fuzzy Throttle and Brake Control for Platoons of Smart Cars**

*Hyun Mun Kim, Julie Dickerson, Bart Kosko*  
Additive fuzzy systems comprising throttle and brake controllers can control velocity and the gap between cars in single lane platoons. A logic switch for throttle and brake decides which system to use. The gap controller uses only data from its own sensors and there is no communication among cars.  
UCB-ITS-PRR-95-42  
December 1995, 47 pp, \$10.00

**Modeling and Control Design for a Computer Controlled Brake System**

*H. Raza, Z. Xu, P. Ioannou, B. Yang*  
The brake model is developed using experiments conducted on a test bench with a full-scale brake subsystem from a Lincoln town car and a computer controlled actuator designed by Ford. Simulation results show that the proposed controller guarantees no overshoot and zero steady state error for step inputs.  
UCB-ITS-PRR-95-37  
November 1995, 37 pp, \$10.00

## SYSTEMS

**Benefits and Impacts Assessments**

**Assessing the Benefits of a National ITS Architecture**

*Mark Hickman, Stein Weissenberger, Joy Dahlgren*  
Principal beneficial features of the national architecture are: 1) a framework for system integration; 2) common data and functions; and, 3) open interface standards. These characteristics are likely to result in lower system costs and higher benefits for ITS users as well as product suppliers.  
UCB-ITS-PWP-96-10  
August 1996, 16 pp, \$5.00

**Evaluation of the I-110 Corridor Smart Card Demonstration Project**

*Genevieve Giuliano, James E. Moore II*  
The Smart Card advanced fare payment system offers significant potential for increasing transit productivity and service quality. This evaluation of Phase II of the demonstration

covers functional performance of hardware and software Smart Card components; impacts on transit management, operations and efficiency; transit passenger responses and perceptions; and institutional and organizational issues.  
UCB-ITS-PRR-96-20  
July 1996, 181 pp, \$25.00

**Evaluation Taxonomy for Congestion Pricing**

*Hong K. Lo, Mark D. Hickman, Maura Walstad*  
Our evaluation taxonomy consists of three dimensions: road pricing strategies, impacted groups, and impacts. This taxonomy is intended to be sufficiently broad so that a wide variety of road pricing schemes can be discussed and compared in one framework. Includes a review of previous research in road pricing.  
UCB-ITS-PRR-96-10  
May 1996, 60 pp, \$15.00

**Highway Electrification and Automation Technologies —Regional Impacts Analysis Project: Executive Summary**

*Southern California Association of Governments (SCAG) & Partners for Advanced Transit and Highways (California PATH)*  
How roadway electrification and highway automation could alleviate the transportation-related problems of freeway congestion, air pollution, and dependence on fossil fuels in southern California.  
UCB-ITS-PRR-93-18  
November 1993, 74 pp, \$9.00

**Highway Electrification and Automation Technologies—Regional Impacts Analysis Project: Phase I: Baseline Scenario Data Analysis**

*Southern California Association of Governments (SCAG) & Partners for Advanced Transit and Highways (California PATH)*  
Final report for Phase I. Contains sections on data collected, baseline forecast for 2025, and electrification and automation specification scenarios.  
UCB-ITS-PRR-93-19  
November 1993, 121 pp, \$15.00

**Highway Electrification and Automation Technologies —Regional Impacts Analysis Project: Phase II: Scenario for Advanced Highway Technologies**

*Southern California Association of Governments (SCAG) & Partners for Advanced Transit and Highways (California PATH)*  
Focuses on development of a modeling framework for evaluation of the

impacts of several alternative advanced technologies applied to selected freeway lanes.  
UCB-ITS-PRR-93-20  
November 1993, 249 pp, \$27.00

**Highway Electrification and Automation Technologies —Regional Impacts Analysis Project: Phase III: Impacts Analysis Results**  
*Southern California Association of Governments (SCAG) & Partners for Advanced Transit and Highways (California PATH)*

Focuses on the assessment of regional impacts associated with application of roadway electrification, and automation technologies to selected freeway sections in the Southern California region.  
UCB-ITS-PRR-93-21  
November 1993, 200 pp, \$22.00

**Highway Electrification and Automation Technologies —Regional Impacts Analysis Project: Phase III**  
*Southern California Association of Governments (SCAG) & Partners for Advanced Transit and Highways (California PATH)*  
Appendices: Mobility Statistics  
UCB-ITS-PRR-93-22  
November 1993, 153 pp, \$17.00

**Impacts of Smart Cards on Transit Operators: Evaluation of I-110 Corridor Smart Card Demonstration Project**  
*T. Chira-Chavala, B. Colfman*  
Assesses the cost and benefit implications of the Smart Card system to transit agencies, using data obtained from interviews of transit personnel, independent onboard observations, and personal communications. The evaluation indicates that smart cards work smoothly and reliably in real-world conditions.  
UCB-ITS-PRR-96-17  
June 1996, 52 pp, \$15.00

**Investigation of the Costs of Roadway Traffic Congestion: A Preparatory Step for IVHS Benefits Evaluation**  
*Mark A. Miller, Kayin Li*  
The authors' recommendations for future research developments: 1) a more unified approach to congestion measurement, to improve estimation, 2) techniques for quantifying impacts of congestion that have hitherto been considered qualitatively, and 3) a methodology for quantifying nonrecurring congestion.  
UCB-ITS-PRR-94-15  
May 1994, 51 pp, \$7.00

**Los Angeles Smart Traveler Field Operational Test Evaluation**  
*Genevieve Giuliano, Randolph W. Hall, Jacqueline M. Golob*  
In response to the Northridge Earthquake of January 1994, an original limited scale FOT based on the I-110 (Harbor Freeway) corridor was switched to target the earthquake affected areas., which greatly broadened the scope of the evaluation.  
UCB-ITS-PRR-95-41  
December 1995, 200 pp, \$35.00

**Market for IVHS: A Research Perspective**  
*Randolph W. Hall*  
Brief background information is given on the California PATH Program, followed by a discussion of benefits evaluation and technology partnerships.  
TECH MEMO-93-2  
July 1993, 11 pp, \$5.00

**Modeling IVHS Emission Impacts Volume 1: Background Issues and Modeling Capabilities**  
*Randall Guensler, Simon Washington, Daniel Sperling*  
Examines general relationships between IVHS technology bundle characteristics and vehicle emission impacts. Primary impacts addressed are those associated with changes in the average speed and operating mode characteristics (acceleration, deceleration, cruise, and idle) of the vehicle.  
UCB-ITS-PWP-94-10  
October 1994, 112 pp, \$13.00

**Modeling IVHS Emission Impacts Volume 2: Assessment of the CALINE 4 Line Source Dispersion Model**  
*Simon Washington, Randall Guensler, Daniel Sperling*  
This report assesses the ability of the emission estimating algorithms contained in the CALINE 4 model developed by Caltrans to accurately predict carbon monoxide emissions from a fleet of motor vehicles.  
UCB-ITS-PWP-94-11  
August 1994, 109 pp, \$13.00

**Observations on European Advanced Traveler Information and Traffic Management Systems**  
*Youngbin Yim, Jean-Luc Ygnace*  
The views presented in the report are largely derived from information gathered at two conferences and from personal interviews with researchers and government authorities engaged in the European IVHS research effort.  
UCB-ITS-PRR-93-23  
January 1993, 80 pp, \$9.00

**Orange County Transit/Traffic Management Integration and Traveler Information Project: Evaluation Plan**  
*Randolph Hall, Mark Hickman*  
Evaluation plan for the Field Operational Test (FOT) of a project to develop an integrated information system for transit and traffic management and for traveler information that relies on GPS (Global Positioning System) equipped buses as probe vehicles.  
UCB-ITS-PWP-96-16  
October 1996, 34 pp, \$10.00

**Potential Contributions of Intelligent Vehicle/Highway Systems (IVHS) to Reducing Transportation's Greenhouse Gas Production**  
*Steven E. Shladover*  
IVHS technologies can promote enhanced operational efficiency and reductions in vehicle miles traveled, changes that could reduce the contribution of the transportation sector to global warming in ways that are explained qualitatively.  
TECH MEMO-91-4  
August 1991, 18 pp, \$5.00

**Potential Payoffs From IVHS: A Framework for Analysis**  
*Rockwell International Science Center*  
Relates the various IVHS functions with the public sector goals they might serve. A new computer tool called DEMOS was used in these analyses.  
UCB-ITS-PRR-92-7  
August 1992, 133 pp, \$15.00

**Potential Payoffs From IVHS: Appendix C**  
*Rockwell International Science Center*  
This Appendix documents the details of the Intelligent Vehicle Highway Systems (IVHS) benefit analysis DEMOS models and provides the PATH user information about what is contained in and how to use the models.  
UCB-ITS-PRR-92-8  
August 1992, 306 pp, \$32.00

**Smart Call Box Field Operation Test Evaluation: Summary Report**  
*James H. Banks, Patrick A.D. Powell*  
Smart call boxes are enhanced emergency call box devices that comprise a microprocessor, cellular communications transceiver, solar power sources, data collection devices, maintenance computers, and data recording systems. The Field Operation Test evaluated the feasibility and cost-effectiveness of using them for traffic census, incident detection, hazardous weather re-

porting, changeable message sign control, and video surveillance.  
UCB-ITS-PRR-97-3  
January 1997, 41 pp, \$10.00

**Smart Corridor Evaluation Plan: Conceptual Design**  
*Mark Miller, Asad Khattak, Randolph W. Hall, Genevieve Giuliano, James Moore, Martin Wachs*  
The specific objectives of this report are to: 1) develop a conceptual structure for the Smart Corridor evaluation, 2) define evaluation data requirements and collection procedures, and 3) select and/or develop data reduction and data analysis methodologies.  
UCB-ITS-PRR-94-1  
February 1994, 61 pp, \$7.00

**Systematic Evaluation of the Impacts of Real-Time Traffic Condition Information on Traffic Flow**  
*Jeffrey L. Adler, Wilfred W. Recker, Michael G. McNally*  
Studies drivers' reaction to real-time traffic information. Involves development of a theoretical model for driver behavior, interactive simulation experiments, data analysis, and behavioral modeling.  
UCB-ITS-PRR-93-6  
June 1993, 119 pp, \$12.00

**Transportation Modeling for the Environment**  
*Matthew J. Barth, Joseph M. Norbeck*  
Describes research dealing with vehicle emissions associated with AHS and ramp metering.  
UCB-ITS-PRR-94-27  
December 1994, 76 pp, \$9.00

**TravInfo Evaluation: Institutional Element Phase 1 Results**  
*Randolph W. Hall, Y.B. Yim, Brian Pfeifle, Stein Weissenberger*  
The TravInfo project aims to develop a multi-modal traveler information system for the San Francisco Bay Area, developing a partnership between the public and private sectors. This report presents the results of the first wave of institutional interviews, as part of the TravInfo evaluation.  
UCB-ITS-PWP-95-1  
February 1995, 51 pp, \$15.00

**TravInfo Evaluation: Institutional Element Phase 2 Results**  
*Randolph Hall, Dimitri Loukakos, Stein Weissenberger, Y.B. Yim*  
Results of year two of the institutional evaluation. TravInfo aims to develop a multimodal traveler information system for the San Francisco Bay Area, combining public and private sector resources. This



year was dominated by implementation issues.

UCB-ITS-PWP-96-14

August 1996, 37 pp, \$10.00

#### **TravInfo Evaluation Plan**

*Youngbin Yim, Asad Khattak,*

*Mark Miller, Randolph Hall*

The TravInfo project is a field operational test of a centralized database in the San Francisco Bay Area.

UCB-ITS-PWP-93-16

November 1993, 42 pp, \$7.00

#### **TravInfo Evaluation: Traveler Response Element Broad Area Study**

*Y.B. Yim, Randolph Hall,*

*Stein Weissenberger*

The study's purpose was to define Bay Area travelers' baseline attitudes, opinions, and travel behavior to help assess the general impact of TravInfo. Three quarters of the participants listen to traffic reports at least on occasion and about half of those who listen change travel habits as a result of traveler information.

UCB-ITS-PWP-97-9

March 1997, 27 pp, \$10.00

#### **TravInfo Evaluation: Value Added Reseller (VAR) Study Phase 1 Results**

*Dimitri Loukakos, Randolph Hall,*

*Stein Weissenberger, Y.B. Yim*

This working paper is part of the Technology Element of the TravInfo evaluation. It presents the results of the "before" wave of the Value-Added-Reseller (VAR) study, in which 17 TravInfo registered VARs and 16 non-registered VARs were interviewed.

UCB-ITS-PWP-96-13

August 1996, 44 pp, \$10.00

#### **TravInfo Evaluation Plan: Update 1**

*Youngbin Yim, Asad Khattak, Mark*

*Miller, Randolph Hall,*

*Stein Weissenberger*

TravInfo is a Field Operational Test of a centralized database, formed through a public/private partnership, that provides easy access to real-time travel information on all modes of transportation in the San Francisco Bay Area. This report presents an update to the TravInfo evaluation plan, concluding with the system performance evaluation.

UCB-ITS-PWP-94-3

March 1994, 66 pp, \$7.00

#### **TravInfo Field Operational Test Traveler Information Center (TIC) Study (Technology Evaluation Element) Implementation Plan**

*Mark A. Miller, Randolph Hall*

The Traveler Information Center is TravInfo's hub for data collection, processing, and dissemination. Thus

the TIC study will focus on TravInfo's overall goal of implementing a system of collecting, integrating, and broadly disseminating timely and accurate traveler information throughout the Bay Area.

UCB-ITS-PWP-95-14

November 1995, 29 pp, \$10.00

#### **TravInfo Field Operational Test Evaluation Plan**

*Randolph Hall, Y.B. Yim, Asad Khattak,*

*Mark Miller, Stein Weissenberger*

Describes scope, methods, and procedures to measure the effectiveness of the project. The TravInfo evaluation will contain four evaluation elements: institutional, technology, traveler response, and network performance.

UCB-ITS-PWP-95-4

May 1995, 64 pp, \$15.00

#### **■ Communications**

##### **ATCOMM/XL Hardware Driver**

###### **Software Documentation**

*Herb Huang, Bret Foreman*

Complete implementation details for the driver-level software to control the Metacomp ATComm/XL serial communication control board. The software is developed in the C++ language and runs the QNX realtime operating system. This driver is specifically intended for use in an infrared wireless communication system.

Tech Note 95-1

January 1995, 11pp, \$5.00

##### **Communication Requirements and Network Design for IVHS**

*Ivy Pei-Shan Hsu, Jean Walrand*

The communication needs between vehicles and the roadside infrastructure are estimated in terms of message length, frequency, and acceptable delay.

UCB-ITS-PWP-93-18

November 1993, 51 pp, \$7.00

##### **Communication System for the Control of Automated Vehicles**

*Sonia R. Sachs, Pravin Varaiya*

Special emphasis is placed on the more demanding requirements placed by AVCS functions. Presents a communication system architecture that features a 'movable microcell' as an addressable network entity.

TECH MEMO-93-5

September 1993, 60 pp, \$7.00

##### **Design and Implementation of Digital Radio Communications Link for Platoon Control Experiments**

*Wei-Yi (William) Li*

Examines the intervehicle communication links implemented in both two- and four-vehicle platoon

experiments, and investigates some possible future improvements of the communication link used for platoon control experimentation.

UCB-ITS-PRR-95-2

January 1995, 62 pp, \$7.00

##### **Discussion of the WaveLAN Radio as Relevant to Automated Vehicle Control Systems**

*Chao Chen, Bret Foreman*

WaveLAN radio is currently being used to implement control loop communication in PATH research. This study shows that due to limited bandwidth, WaveLAN is adequate for only one platoon per cell.

Tech Note 96-1

April 1996, 18 pp, \$5.00

##### **Evaluation of Radio Links and Networks**

*Jean-Paul M.G. Linnartz,*

*Rolando F. Diesta*

A contribution to the modeling of short range vehicle-to-vehicle channels, not only in terms of documenting measured results and channel parameters, but also in extending existing models to cover antenna mobility at both receiver and transmitter simultaneously.

UCB-ITS-PRR-96-16

June 1996, 107 pp, \$20.00

##### **Integrated Physical/Link-Access Layer Model of Packet Radio Architectures**

*Andreas Polydoros: contributors*

*Achilleas Anastasopoulos, Te-Kai Liu,*

*Prokopios Panagiotou, Chung-ming Sun*

This report contributes to a generic conceptual model for system evaluation that can be used for quantification of the interaction between network layers.

UCB-ITS-PRR-94-20

October 1994, 20 pp, \$22.00

##### **Integrated Physical/Link-Access Layer Model of Packet Radio Architectures**

*Andreas Polydoros*

Contributes to a generic conceptual model for system evaluation that can be used for quantification of the interaction between network layers.

UCB-ITS-PRR-95-33

September 1995, 126 pp, \$20.00

##### **Infrared Datalink Layer Documentation**

*Herb Huang, Bret Foreman*

Describes the datalink layer (DL) software for an infrared communication link. The software is designed to fit in the structure of an intervehicle communication system.

Tech Note 95-2

January 1995, 9 pp, \$5.00

##### **Monitoring the San Francisco Bay Area Freeway Network Using Probe Vehicle and Random Access Radio Channel**

*Jean-Paul M.B. Linnartz, Marcel*

*Westerman, Rudi Hamerslag*

Results presented reveal that random access (ALOHA) transmission of traffic messages is a (spectrum) efficient, inexpensive, and flexible method for collecting road traffic data and that this approach can provide reliable traffic monitoring.

UCB-ITS-PRR-94-23

October 1994, 60 pp, \$7.00

##### **Outdoor Measurements on WaveLAN Radio**

*Chao Chen, Manjari Asawa,*

*Bret Foreman*

This study looks at outdoor propagation measurements performed on WaveLAN radio in a simulated platoon environment. Results indicate that the channel between vehicles at the front and rear ends of a platoon suffers from fading.

Tech Note 96-2

April 1996, 14 pp, \$5.00

##### **Spectrum Needs for IVHS**

*Jean-Paul M.G. Linnartz,*

*Jean Walrand*

Summarizes the need for a (dedicated) radio spectrum for IVHS communication services, and concludes that if efficient architectures can be developed, several MHz of spectrum will be needed for large-scale introduction of IVHS services.

UCB-ITS-PWP-93-13

September 1993, 29 pp, \$7.00

##### **Towards a Fault Tolerant AHS Design Part II: Design and Verification of Communication Protocols**

*D.N. Godbole, J. Lygeros, E. Singh, A.*

*Deshpande, A.E. Lindsey*

Presents the design and verification of intervehicle communication protocols for degraded modes of operation on an Automated Highway System (AHS). Considers hardware and sensor faults that might develop on an automated vehicle, and designs supervisory controllers to stop a faulty vehicle or take it off the highway.

UCB-ITS-PRR-96-15

June 1996, 41 pp, \$10.00

##### **Ultrasonic Ranging Control Board Documentation**

*Jennie Chen, Bret Foreman,*

*Kirill Mostov*

Presents an experimental ultrasonic control board designed to run various tests to determine the performance of ultrasonics in a platoon situation. Specifies the theory of operation of version B of the PATH

ultrasonic range control board for the IBM PC.  
UCB-ITS-PWP-94-9  
Revised July 1994, 80 pp, \$9.00

#### **Vehicle to Roadside Communications Study**

*Andreas Polydoros, Khaled Dessouky, Jorge M.N. Pereira, Chung-ming Sun, Kuo-chun Lee, Thomas D. Papavassiliou, Victor O.K. Li*

This study emphasizes the architecture and topology aspects of the physical link and access layers connecting moving layers with the fixed infrastructure.

UCB-ITS-PRR-93-4  
June 1993, 316 pp, \$33.00

#### **Dynamic System Modeling**

##### **Control of Discrete Event Systems in Temporal Logic**

*Akash Deshpande, Pravin Varaiya*  
This paper presents two approaches to the control of a discrete event system (DES) within the framework of Propositional Linear Temporal Logic (PLTL). Given the plant behavior and the desired behavior, both described in PLTL, a causal, nonblocking and fair controller is to be synthesized that restricts the system's closed loop behavior to a subset of the desired behavior.  
Tech Note 94-4  
August 1994, 39 pp, \$7.00

##### **Control of Hybrid Systems**

*Akash Deshpande, Pravin Varaiya*  
To formulate the overall AVCS System, one needs a mathematical framework in which a discrete state system interacts with a set of traditional continuous variable systems. These systems are called hybrid systems. This report, the first in a series documenting work in hybrid systems, develops some theory.  
TECH MEMO-93-1  
June 1993, 33 pp, \$7.00

##### **Dynamic Visualization Environment for the Design and Evaluation of Automatic Vehicle Control Systems**

*Z. Xu*  
Summarizes the development of software that can animate automated highways, visualize the dynamics of automatic vehicles, and assist in the design and evaluation of automatic vehicle systems.  
UCB-ITS-PRR-95-45  
December 1995, \$10.00

##### **DYNAVIS: A Dynamic Visualization Environment for the Design and Evaluation of Automatic Vehicle Control Systems**

*A. Kanaris, Z. Xu, J. Hauser*  
DYNAVIS is an interactive engineering environment developed specifi-

cally for the design and evaluation of automatic longitudinal and lateral vehicle control systems. DYNAVIS goes far beyond simple animation systems by providing a set of tools to perform interactive visualization with on-line modification of many visualization parameters, such as time and space resolution systems.

Tech Note 94-8  
November 1994, 11 pp, \$5.00

##### **Hierarchical Hybrid Control: A Case Study**

*Datta N. Godbole, John Lygeros, Shankar Sastry*  
Points out that conventional tools currently in use for the design and verification of control systems may be inadequate for the design of hierarchical control of hybrid systems. The analysis also indicates certain shortcomings of current IVHS design, and proposes solutions to fix these problems.  
UCB-ITS-PRR-95-9  
April 1995, 31 pp, \$10.00

##### **Indirect Adaptive Control of a Class of Interconnected Nonlinear Dynamical Systems**

*Shahab Sheikhholeslam, Charles A. Desoer*  
Proposes a local indirect adaptive control scheme for the class of interconnected nonlinear dynamical systems suggested by the problem of longitudinal and lateral control of a platoon of vehicles on automated highways.  
TECH MEMO-91-1  
August 1991, 33 pp, \$7.00

##### **Interface Between Continuous and Discrete-Event Controllers for Vehicle Automation**

*John Lygeros, Datta Godbole*  
The design proposed is a finite state machine that communicates with the discrete controllers by issuing commands that get translated to "jerk" input for the vehicle engine.  
UCB-ITS-PRR-94-12  
April 1994, 25 pp, \$5.00

##### **Object Management Systems**

*Aleks Ohannes Göllü*  
Demonstrates the use of the SmartAHS simulation framework by implementing elements of the PATH automation architecture. The resultant OMS application is called SmartPATH.  
UCB-ITS-PRR-95-19  
June 1995, 179 pp, \$25.00

##### **Steady State Conditions on Automated Highways**

*José M. del Castillo, David J. Lovell, Carlos F. Daganzo*  
Estimates are made of the steady-state capacity of automated high-

ways, with particular attention to the effect of entry and exit maneuvers. The possibility of scheduling departing vehicles appropriately into platoons to minimize extraneous maneuvers is investigated. Characteristics of urban areas likely to be candidates for automated freeways are discussed.  
UCB-ITS-PWP-96-5  
June 1996, 25 pp, \$10.00

##### **Sy-Control: A Tool for Syntactic Control in Temporal Logic**

*Akash Deshpande, Pravin Varaiya*  
This paper describes Sy-Control, a software tool for syntactic control of discrete event systems (DES). Sy-Control use is illustrated in terms of a simulated application to a critical intersection in Toronto's Queen Street corridor using real data.  
Tech Note 94-5  
August 1994, 14 pp, \$5.00

##### **Time Space Diagrams for Thirteen Shock Waves**

*Benjamin Coifman*  
Presents microscopic time-space diagrams for several shock waves over 100-200m distances. The primary focus of the paper is on presenting the data rather than analysis. The diagrams should be of general interest to researchers studying traffic congestion.  
UCB-ITS-PWP-97-1  
January 1997, 21 pp, \$5.00

#### **Electric and Hybrid Vehicles**

##### **Evaluation of Potential Hybrid Electric Vehicle Applications: Volume 1**

*Arturo E. Gris*  
Covers topics including energy and power requirements, battery and range extender, propulsion system, and air conditioning.  
UCB-ITS-PRR-91-4  
1991, 93 pp, \$10.00

##### **Evaluation of Potential Hybrid Electric Vehicle Applications: Volume II: Appendices**

*Arturo E. Gris*  
Identifies potentially promising market segments for electric and hybrid vehicle technologies.  
UCB-ITS-PRR-91-5  
1991, 165 pp, \$19.00

##### **Feasibility Study of Advanced Technology HOV Systems. Vol 2A: Feasibility of Implementing Roadway-Powered Electric Vehicle Technology in El Monte Busway: A Case Study**

*T. Chira-Chavala, Edward H. Lechner, Dan M. Empey*  
Assesses the feasibility of early deployment of RPEV technology in

existing HOV facilities in California.  
UCB-ITS-PRR-92-3  
December 1992, 129 pp, \$13.00

##### **Feasibility Study of Advanced Technology HOV Systems. Volume 2B: Emissions Impact of Roadway-Powered Electric Buses, Light-Duty Vehicles and Automobiles**

*Mark A. Miller, Victor Dato, Ted Chira-Chavala*  
Investigates potential near-term air quality benefits due to RPEV's relative to internal-combustion engine vehicles under identical operating conditions.  
UCB-ITS-PRR-92-4  
December 1992, 112 pp, \$12.00

##### **Highway Electrification and Automation**

*Steven E. Shladover*  
Addresses how the California Department of Transportation and the California PATH Program have made efforts to evaluate the feasibility and applicability of highway electrification and automation technologies. Experimental results, design study results, and a region-wide application impacts study for Los Angeles.  
UCB-ITS-PRR-92-17  
December 1992, 35 pp, \$7.00

##### **Highway Electrification: An Exploration of Energy Supply Implications**

*Quanlu Wang, Daniel Sperling*  
The relationship between transportation and electricity demand patterns are investigated for different regions of the country. Implications of electrifying highway transportation for the electricity industry are identified.  
UCB-ITS-PWP-87-4  
1987, 41 pp, \$7.00

##### **Roadway Powered Electric Vehicle Project Parametric Studies: Phase 3D Final Report**

*Systems Control Technology, Inc.*  
Examines the application of electrification and automation to freeways in the Los Angeles region. The report is broken down into the following sections: development and enhancement of analysis tools, inductive coupling system design, value engineering of roadway cores, and economic analysis of roadway powered electric vehicle (RPEV) technology.  
UCB-ITS-PRR-96-28  
October 1996, 176 pp, \$25.00

##### **Roadway Powered Electric Vehicle Project, Track Construction and Testing Program**

*Systems Control Technology, Inc.*  
This report covers the construction and testing of an RPEV proof-of-concept system built at the University of California Richmond Field



Station. The facility has a 700-foot test track and an operational 35-passenger RPEV.  
UCB-ITS-PRR-94-7  
March 1994, 322 pp, \$34.00

## ■ Heavy Vehicles

### **Analysis, Design, and Evaluation of AVCS for Heavy-Duty Vehicles**

*Diana Yanakiev,*

*Ioannis Kanellakopoulos*

Develops two new nonlinear spacing policies—variable time headway and variable separation error gain—that all but eliminate the large steady-state intervehicle spacings characteristic of heavy-duty vehicles. The first policy allows us to use much smaller spacings in autonomous platoon operation; the second results in smoother and more robust longitudinal control.

UCB-ITS-PRR-96-26

September 1996, 39 pp, \$10.00

### **Analysis, Design, and Evaluation of AVCS for Heavy-Duty Vehicles: Phase 1 Report**

*Diana Yanakiev,*

*Ioannis Kanellakopoulos*

After a brief description of the dynamic model used in the design and simulations, the authors develop nonlinear controllers with adaptation, first for speed control and then for vehicle follower longitudinal control. Both autonomous operation and intervehicle communication are considered.

UCB-ITS-PWP-95-12

August 1995, 39 pp, \$10.00

### **Communications and Positioning Systems in the Motor Carrier Industry**

*Dimitris A. Scapinakis,*

*William L. Garrison*

New technologies for determining the positions of trucks and for communications to and from trucks are reviewed. The potential for integration of information from the trucking industry has not yet been considered by the IVHS community.

UCB-ITS-PRR-91-10

1991, 81 pp, \$10.00

### **Dynamic Modeling of Tractor-Semitrailer Vehicles in Automated Highway Systems**

*Chieh Chen, Masayoshi Tomizuka*

Characterizes the dynamic response parameters, develops control algorithms to achieve automatic guidance, and describes experiments on lateral guidance control of articulated heavy-duty vehicles. Also describes a modeling approach for roll,

pitch and yaw motions of tractor-semitrailer vehicles.

UCB-ITS-PWP-95-8

July 1995, 24 pp, \$5.00

### **Engine and Transmission Modeling for Heavy-Duty Vehicles**

*Diana Yanakiev,*

*Ioannis Kanellakopoulos*

In this report, the authors present an overview of engine and transmission modeling for heavy-duty vehicles.

The models constructed are suitable for control design and simulation, and they are used in the Advanced Vehicle Control Systems (AVCS) design for trucks and buses.

Tech Note 95-6

August 1995, 63 pp, \$15.00

### **Freight Transportation and Highway Automation: Research on Advanced Technologies for Goods Movement as an Integral Part of the PATH Program**

*Ann D. Stevens*

Good design builds flexibility into itself. PATH participants can enhance their design capabilities by studying the paths taken so far by passenger and freight systems and recognizing similar patterns.

UCB-ITS-PWP-87-2

December 1987, 21 pp, \$5.00

### **Lateral Control of Commuter Buses**

*Pushkar Hingwe, Masayoshi Tomizuka*

Presents two approaches to the design of lateral controllers for commuter buses based on Sliding Mode Control (SMC).

UCB-ITS-PWP-95-9

July 1995, 22 pp, \$5.00

### **Lateral Control of Tractor-Semitrailer Vehicles in Automated Highway Systems**

*Chieh Chen, Masayoshi Tomizuka*

Linear quadratic optimal control with and without frequency shaping is utilized to design a steering controller for tractor-semitrailer vehicles in Automated Highway Systems (AHS). To enhance driving safety, we propose to use independent braking forces in the trailer as another control input.

UCB-ITS-PRR-96-33

November 1996, 29 pp, \$10.00

### **Organizing for ITS: Computer Integrated Transportation Phase 2: Results for Commercial Vehicle Operators**

*Randolph Hall, Indrajit Chatterjee*

Extends the research on Computer Integrated Transportation to commercial vehicle operations (CVO), specifically to examine how govern-

ment can work with trucking companies (i.e., "motor carriers") within a CIT framework.

UCB-ITS-PWP-95-15

November 1995, 55 pp, \$15.00

### **Studies of the Adoption and Use of Location and Communication Technologies by the Trucking Industry**

*Dimitris A. Scapinakis,*

*William L. Garrison*

Describes eight tasks to be undertaken in an investigation of communication technologies in the trucking industry.

UCB-ITS-PRR-91-2

1991, 20 pp, \$5.00

## ■ Transportation Modeling

### **Are the Objectives and Solutions of Dynamic User-Equilibrium Models Always Consistent?**

*Wei-Hua Lin, Hong Lo*

Examines the general form of dynamic user-equilibrium traffic assignment (DUETA) models and shows that if queuing behavior is represented in the model at a minimal level, the solution to conventional DUETA models may not necessarily converge to or approximate the Wardropian user-equilibrium condition in the dynamic sense.

UCB-ITS-PWP-96-6

June 1996, 14 pp, \$5.00

### **BTS (Version 1.0) - Bottleneck Traffic Simulator User's Manual**

*Wei Hua Lin, Randolph W. Hall*

Describes the computer program BTS, a macroscopic tool for simulating the performance of freeway bottlenecks.

UCB-ITS-PWP-91-1

March 1991, 27 pp, \$5.00

### **BTS (Version 1.1) - Bottleneck Traffic Simulator User's Manual**

*Wei H. Lin, Randolph W. Hall*

This new version of BTS was enhanced to include incident dependencies, variable weather conditions, reneging, and randomly varying traffic volumes.

UCB-ITS-PWP-91-6

July 1991, 31 pp, \$5.00

### **Cell Transmission Model: Network Traffic**

*Carlos F. Daganzo*

Shows how the evolution of multicommodity traffic flows over complex networks can be predicted over time, based on a simple macroscopic computer representation of traffic flow that is consistent with the kinematic wave theory under all traffic conditions.

UCB-ITS-PWP-94-12

August 1994, 18 pp, \$5.00

### **Cell Transmission Model. Part I: A Simple Dynamic Representation of Highway Traffic**

*Carlos F. Daganzo*

This representation can be used to predict traffic's evolution over time and space, including transient phenomena such as the building, propagation and dissipation of queues. The representation's simplicity should make it possible to keep track of each vehicle's final destination throughout a simulation, even for complex networks.

UCB-ITS-PRR-93-7

July 1993, 60 pp, \$7.00

### **ComBehQ: A Combined Behavioral and Queuing Model User's Guide**

*Asad Khattak, Haitham Al-Deek,*

*Paramsothy Thananjeyan*

The model offers a framework for assessing the impacts of auto-related ATIS technologies during incident related congestion.

Tech Note 95-5

July 1995, 42 pp, \$10.00

### **Comparison of Traffic Models: Part I-Framework**

*Hong K. Lo, Wei-Hua Lin, Lawrence C.*

*Liao, Elbert Chang, Jacob Tsao*

Emphasizes four dimensions: functionality, traffic dynamics, route choice dynamics, and overall network performance. Also included are a list of performance measures, for comparison purposes, and a discussion of the interpretation of results.

UCB-ITS-PRR-96-22

August 1996, 56 pp, \$15.00

### **Continuum Theory of Traffic Dynamics for Freeways with Special Lanes**

*Carlos F. Daganzo*

The proposed simple model is attractive because its mathematical formulation requires very few data that are easy to obtain, and also because its solution can be described completely by a set of diagrams that are intuitive.

Tech Note 95-8

December 1995, 46 pp, \$10.00

### **Decision Support and Consensus Building for PLANITS**

*Adib Kanafani, Melanie Crotty*

PATH researchers have developed a framework to integrate planning and analysis in a computer-supported environment that facilitates deliberation and consensus seeking. This framework is called Planning and Analysis to Integrate Intelligent Urban Transportation Systems or PLANITS.

UCB-ITS-PWP-93-20

November 1993, 49 pp, \$7.00

**Development of a Dynamic Equilibrium Assignment Procedure for Network-Level Analysis of New Technology**

*Edward C. Sullivan, Sun Wong*

Identifies a network traffic assignment procedure to be used in the analysis and evaluation of new technologies deployed in selected corridors containing High Occupancy Vehicle (HOV) facilities.

UCB-ITS-PRR-89-4

August 1989, 92 pp, \$11.00

**Enhancements to a Simulation Framework for Analyzing Urban Traffic Networks with ATIS/ATMS**

*R. Jayakrishnan, Unmesh Rathi, Craig Rindt, Ganesh Vaideeshwaran*

The DYNASMART simulation program, developed at UC Irvine with PATH funding, has been enhanced to include full-scale traffic signal control as well as freeway ramp control. It is now capable of simulating large urban networks and evaluating benefits from candidate ATIS and ATMS strategies.

UCB-ITS-PRR-96-27

October 1996, 70 pp, \$15.00

**Evaluation of Highway Bottlenecks**

*Randolph Hall, M. Kamoun*

Final report of the PATH research project "Bottleneck Evaluation Model." Key issues include the effects on (1) incident frequency, duration and reliability; and (2) changes in traveler behavior, in the forms of arrival time choice and reneging.

UCB-ITS-PRR-91-9

July 1991, 42 pp, \$7.00

**Ideal Dynamic User-Optimal Route Choice: A Link-based Variational Inequality Formulation**

*Bin Ran, David E. Boyce*

Presents traffic network constraints and link-based DUO route choice conditions, and introduces a link-based variational inequality (VI) formulation that avoids route enumeration in both the formulation and the solution procedure.

UCB-ITS-PWP-95-7

May 1995, 27 pp, \$10.00

**Link-Based Variational Inequality Model for Dynamic Departure Time/Route Choice**

*Bin Ran, Randolph W. Hall, David E. Boyce*

The dynamic user-optimal (DUO) departure time and route choice problem is to determine travelers' best departure times and route choices at each instant of time. The authors present a formulation for the problem that avoids route enumeration

in both formulation and solution procedure.

UCB-ITS-PWP-95-6

May 1995, 34 pp, \$10.00

**Model Selection and Initial Application of CONTRAM Model for Evaluation In-Vehicle Information Systems**

*Yonnel Gardes, Bruce Haldors, Adolf D. May*

An initial evaluation of in-vehicle information systems and the applicability of the model is made.

UCB-ITS-PRR-91-11

June 1991, 166 pp, \$18.00

**PLANiTS: The Case-based Reasoner as a Planning Tool for Intelligent Transportation Systems**

*Asad Khattak, Adib Kanafani*

Develops a data synthesis methodology in PLANiTS using case-based reasoning. Also discuss issues related to computer implementation and the limitations of case-based reasoning.

UCB-ITS-PRR-95-23

July 1995, 26 pp, \$10.00

**PLANiTS: A Functional Description**

*Asad Khattak, Adib Kanafani*

Describes Planning and Analysis Integration for Intelligent Transportation Systems, a process-based computer system that translates transportation project problems and goals to performance measures, examines possible competing and complementary actions that can address the problems, systematically evaluates the impacts of actions by using appropriate knowledge-based and model-based tools, and supports human communication and interaction between planning group members.

UCB-ITS-PRR-95-7

March 1995, 41 pp, \$10.00

**PLANiTS: The Methods Base, Model Selection and Model Integration**

*Rosella Picado, Asad Khattak, David J. Lovell, Adib Kanafani*

Functions of the Methods Base discussed include representation of model chains, selection of models and data, and data transformations and aggregation. The Methods Base features are illustrated with an example drawn from the PLANiTS prototype (version 1.0).

UCB-ITS-PRR-95-16

May 1995, 60 pp, \$15.00

**PLANiTS: Organization and Integration of Modules**

*Thananjeyan Paramsothy, Asad Khattak, David Lovell, Adib Kanafani*

Discusses the integration of PLANiTS components, which is achieved by defining a structure for representing transportation improvement actions,

performance measures and environment in terms of spatial, temporal and user dimensions.

UCB-ITS-PRR-95-18

June 1995, 45 pp, \$10.00

**PLANiTS: A User's Guide for the Prototype**

*Randall Cayford, Asad Khattak, Adib Kanafani*

The prototype has a planning vector that allows users to enter and edit transportation actions, performance measures and environmental descriptors. This guide demonstrates how users specify each of these elements in terms of temporal, spatial, and user dimensions and analyze the planning vector with models and case-based reasoning.

UCB-ITS-PRR-95-13

May 1995, 25 pp, \$5.00

**Planning Methodology for Intelligent Urban Transportation Systems**

*Adib Kanafani, Asad Khattak, Melanie Crotty, Joy Dahlgren*

This study presents a framework for integrating planning and analysis in a computer supported environment that facilitates deliberation and consensus seeking.

UCB-ITS-PRR-93-14

June 1993, 120 pp, \$14.00

**Properties of Link Travel Time Functions Under Dynamic Loads**

*Carlos F. Daganzo*

Shows that such functions only make some physical sense in the special case where each function denotes either a link with no spatial dimension containing a point queue, or a link with constant travel time and no queuing.

UCB-ITS-PWP-93-5

August 1993, 10 pp, \$5.00

**Rapid Prototyping of Advanced Driver Interface Systems**

*Lauren J. Massa, Max B. Mendel*

This report describes a computer environment for rapidly prototyping user interfaces for advanced driver information systems (ADIS).

UCB-ITS-PRR-93-8

August 1993, 20 pp, \$5.00

**Simulation of IVHS on the Smart Corridor Using the INTEGRATION Mode**

*Yonnel Gardes, Adolf D. May*

Describes Phase I of the project, in which the INTEGRATION traffic simulation model is used to help simulate ATIS and ATMS on a freeway/arterial environment.

UCB-ITS-PRR-93-3

May 1993, 90 pp, \$10.00

**Simple Detection Scheme for Delay-Inducing Freeway Incidents**

*Wei-Hua Lin, Carlos F. Daganzo*

Describes a freeway incident detection algorithm based on an intrinsic property of delay-inducing incidents without relying on complex theories of traffic behavior. The procedure compares the occupancy information recorded by two neighboring loop detectors to determine whether an incident has occurred in the intervening segment.

Tech Note 96-4

April 1996, 32 pp, \$10.00

**Simple Physical Principle for the Simulation of Freeways with Special Lanes and Priority Vehicles**

*Carlos Daganzo, Wei-hua Lin, José M. del Castillo*

Presents a remarkably simple physical principle that can be used to solve the kinematic wave problem for freeways with special lanes and priority vehicles.

Tech Note 95-9

December 1995, 39 pp, \$10.00

**SmartPath: An Automated Highway System Simulator**

*Farokh Eskafi, Delnaz Khorramabadi, Pravin Varaiya*

SmartPath is a simulator for an AHS. This document explains how the simulation is organized: an example illustrates the use of SmartPath.

TECH MEMO-92-3

October 1992, 51 pp, \$5.00

**SmartPath User's Manual**

*Farokh Eskafi, Delnaz Khorramabadi*

Instruction on how to compile, run, and use all modules of SmartPath in both the batch or interactive modes.

Tech Note 94-2

June 1994, 24 pp, \$5.00

**Simulation-Based Framework for the Analysis of Traffic Networks Operation with Real-Time Information**

*R. Jayakrishnan, Michael Cohen, John Kim, Hani S. Mahmassani, Ta-Yin Hu*

Discusses the simulation approach of DYNASMART. Results from the simulation of traffic management for special-events traffic from the Anaheim stadium are presented.

UCB-ITS-PRR-93-25

November 1993, 96 pp, \$11.00

**Simulation of IVHS on the Santa Monica Freeway Corridor Using the INTEGRATION Model. Phase 2: Preliminary ATIS and ATMS Experiments**

*Yonnel Gardes, Adolf D. May*

Strategies to be tested include freeway ramp metering, real-time traffic

signal optimization, route-guidance systems, and combinations of these strategies. Investigations are performed for the morning peak period under both incident-free and incident traffic conditions.  
UCB-ITS-PWP-93-6  
August 1993, 43 pp, \$7.00

**Simulation Modeling of the Santa Monica Freeway**

*Loren D. Bloomberg, Adolf D. May*  
Describes the strategies, limitations, and assumptions needed to code the Santa Monica Freeway using the FREQ and INTEGRATION simulation tools. The report ends with indilations and suggestions for future research.  
UCB-ITS-PWP-94-14  
September 1994, 103 pp, \$13.00

**SmartPath Simulator - Version MOU62**

*Bruce Hongola, Jacob Tsao, Randolph Hall*  
User instructions and software design description for version MOU62 of the SmartPath Simulator.  
UCB-ITS-PWP-93-8  
August 1993, 56 pp, \$7.00

**SmartPath Version 2: An Automated Highway System Simulator**

*Farokh Eskafi, Delnaz Khorramabadi, Pravin Varaiya*  
A guide to version 2 of SmartPath.  
Tech Note 94-3  
December 1994, 28 pp, \$5.00

**Spatial Evolution of Queues During the Morning Commute in a Single Corridor**

*Carlos F. Daganzo, Wei-Hua Lin*  
Presents a qualitative description of the evolution of traffic congestion. We found that unreasonable results are obtained with "point queue" models, currently a favored approach in the dynamic traffic assignment literature.  
UCB-ITS-PWP-93-7  
July 1993, 23 pp, \$5.00

**Spatial Evolution of Traffic Under the Two-Wave Speed Assumption: A Shortcut Procedure and Some Observations**

*Carlos F. Daganzo*  
This paper describes the behavior of traffic in a homogeneous highway according to the hydrodynamic theory in the special case where the flow-density relationship is triangular; i.e., when only two wave velocities exist.  
UCB-ITS-PWP-93-3  
July 1993, 25 pp, \$5.00

**Steady State Conditions on Automated Highways**

*José M. del Castillo, David J. Lovell, Carlos F. Daganzo*  
Estimates are made of the steady-state capacity of automated highways, with particular attention to the effect of entry and exit maneuvers. The possibility of scheduling departing vehicles appropriately into platoons to minimize extraneous maneuvers is investigated. Characteristics of urban areas likely to be candidates for automated freeways are discussed.  
UCB-ITS-PWP-96-5  
June 1996, 25 pp, \$10.00

**Technical Description of NETCELL: General Framework and Data Structure**

*Wei-Hua Lin, Carlos F. Daganzo*  
Discusses implementation of a prototype of a freeway network simulation program, NETCELL, in detail, including cell representation for a freeway network with three-legged junctions, data and file structures, inputs and outputs, and some key algorithms developed to model traffic progression in junctions.  
Tech Note 94-7  
October 1994, 35 pp, \$7.00

**Theory of Traffic Flow in Automated Highway Systems**

*Mireille Broucke, Pravin Varaiya*  
Our theory is based on an abstraction of vehicle activities like entry, exit, and cruising, derived from a vehicle's automatic control laws. An activity is represented in the flow model by the space occupied by a vehicle engaged in that activity. The theory formulates TMC traffic plans as the specification of the activities and speed of vehicles, and the entry and exit flows for each highway section.  
UCB-ITS-PRR-95-43  
December 1995, 32 pp, \$10.00

**Time Space Diagrams for Thirteen Shock Waves**

*Benjamin Coifman*  
Presents microscopic time-space diagrams for several shock waves over 100-200m distances. The primary focus of the paper is on presenting the data rather than analysis. The diagrams should be of general interest to researchers studying traffic congestion.  
UCB-ITS-PWP-97-1  
January 1997, 21 pp, \$5.00

**Traffic Modeling to Evaluate Potential Benefits of Advanced Traffic Management and In-Vehicle Information Systems in a Freeway/Arterial Corridor**

*Yonnel Gardes, Adolf D. May*  
Includes a literature review of existing traffic simulation models.  
UCB-ITS-PRR-90-3  
1990, 69 pp, \$9.00

**Transportation Modeling for the Environment: Final Report**

*Matthew J. Barth, Joseph M. Norbeck*  
Describes preliminary research on vehicle emissions associated directly with Automated Highway Systems (AHS) and ramp metering. A power-demand model emissions model was integrated with several transportation simulation models in order to quantitatively determine the effects of Intelligent Transportation Systems (ITS) technology on vehicle emissions.  
UCB-ITS-PRR-96-6  
February 1996, 98 pp, \$5.00

**Turning Movement Estimation in Real Time (TMERT)**

*Peter T. Martin*  
Describes a new transportation planning model that can monitor system performance and derive management and control strategies in real time. It offers a method of estimating turning movement flows from link detected flows at small recurrent intervals in real time. The model is shown to be transferable through estimation of turning movements from a real Californian City.  
UCB-ITS-PRR-95-29  
September 1995, 178 pp, \$25.00

**Validating the Basic Cell Transmission Model On a Single Freeway Link**

*Wei-Hua Lin, Dike Ahanotu*  
The cell transmission model, developed as a discrete version of the hydrodynamic theory of traffic flow, is capable of automatically tracking shocks and acceleration waves and thus capturing traffic behavior in the process of the formation, propagation, and dissipation of queues. This note examines the performance of the basic model for both congested and uncongested traffic based on the field data from a segment of I-880 in California.  
Tech Note 95-3  
March 1995, 89 pp, \$15.00

**Transportation Policy and Planning Issues**

**Institutional Challenges to the Development and Deployment of ITS/ATS Systems in California**

*Thomas A. Horan, Lamont C. Hempel, Margo Bowers*  
Findings are based on a series of in-depth interviews and review of research related to "non-technical" constraints both in California and at the national level. The study outlines three core areas that require attention: research collaboration, regional management, and stakeholder acceptance.  
UCB-ITS-PRR-95-17  
May 1995, 114 pp, \$20.00

**ITS and the Environment: Issues and Recommendations for ITS Deployment in California**

*Thomas A. Horan, Lamont C. Hempel, Daniel R. Jordan, Erik A. Alm*  
A two-year, multifaceted inquiry into the environmental issues associated with ITS. Reviews the literature, presents results from focus groups, addresses public acceptance issues, and concludes with summary results and recommendations for devising regional and statewide ITS deployment strategies.  
UCB-ITS-PRR-96-18  
June 1996, 98 pp, \$15.00

**Lean Machines: Preliminary Investigations**

*William L. Garrison, Mark E. Pitstick*  
Information from early work on the potential for the General Motors small and energy efficient Lean Machine vehicle in California markets.  
UCB-ITS-PRR-90-4  
July 1990, 46 pp, \$7.00

**Lessons from Case Studies of Advanced Transportation and Information Systems**

*Joy Dahlgren, Stein Weissenberger, Mark Hickman, Hong Lo*  
This paper poses two key questions regarding ATMIS implementation: How are ATMIS services successfully implemented? In what circumstances are ATMIS strategies cost-effective? The authors attempt to find answers by examining case studies of twelve jurisdictions.  
UCB-ITS-PWP-96-9  
July 1996, 11 pp, \$5.00



**Opportunities and Constraints for Advanced Highway Technologies: A Speculative Analysis**

*Elizabeth A. Deakin*

Considers the possibilities raised by proposed highway technologies and applications, as a basis for the exploration of questions about the technologies' effects.

UCB-ITS-PRR-89-7

October 1989, 48 pp, \$7.00

**Opportunities and Constraints for Advanced Highway Technologies: A Speculative Analysis. Executive Summary**

*Elizabeth A. Deakin*

Discusses technology options, application opportunities, and barriers to the introduction of advanced highway technologies. An executive summary to PATH Research Report 89-7.

UCB-ITS-PRR-89-8

October 1989, 17 pp, \$5.00

**Research and Testing for ITS Deployment and Operation**

*Stein Weissenberger, Joy Dahlgren, Mark Hickman, Hong Lo*

Identifies elements of a publicly sponsored research and testing (R&T) program to best serve the needs of ITS deployment. R&T should help integrate ITS technologies, data flows, services, organizations and user. A key theme will be effective generation and application of information for users, planners, implementors, and operators.

UCB-ITS-PWP-96-8

July 1996, 9 pp, \$5.00

**Restructuring the Automobile/Highway System for Lean Vehicles: The Scaled Precedence Activity Network (SPAN) Approach**

*Mark E. Pitsick, William L. Garrison*

Investigates the introduction of parking and road facilities for lean vehicles: small, one- or two-passenger vehicles that consume less energy and produce less pollution and congestion than present vehicles.

UCB-ITS-PRR-91-7

April 1991, 189 pp, \$20.00

**Role of Teamwork in a Planning Methodology for Intelligent Transportation Systems: Volume 1**

*Adib Kanafani, M. Manheim, A. Khattak, N. Vlahos*

The methodology proposed exploits emerging information technologies to develop decision support for the teamwork found in transportation planning problems. The concept of a Building Block Function is introduced as the functional form of the decision support that the computer system PLANITS should provide.

UCB-ITS-PWP-94-8

May 1994, 33 pp, \$7.00

**Second Annual Symposium on Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS)**

*Adolf May, Bruce Haldors*

Summary of the presentations made at the symposium.

UCB-ITS-PRR-91-1

November 1990, 29 pp, \$5.00

**Small Cars in Neighborhoods**

*Peter C. Bosselmann, Daniel Cullinane, William Garrison, Carl M. Maxey*

Reviews the development of small vehicles and roads suited to their use and considers community development trends that might encourage or thwart the adoption and use of such vehicles.

UCB-ITS-PRR-93-2

April 1993, 87 pp, \$10.00

**Status of Foreign Advanced Highway Technology**

*Adib Kanafani, Howard R. Ross, Robert E. Parsons*

Analyzes conditions in Europe and Japan.

UCB-ITS-PRR-87-2

October 1987, 49 pp, \$7.00

**Studies of Road Infrastructure Requirements for Small Innovative Vehicles**

*William L. Garrison*

Road infrastructure modifications for a 500 to 700 pound, 1 + occupant commuter car include restriping, provision of special lanes, and flyovers. These modifications could sharply increase capacity and could be achieved incrementally at low cost.

UCB-ITS-PRR-93-16

November 1993, 93 pp, \$11.00

**Socioeconomic Attributes and Impacts of Travel Reliability: A Stated Preference Approach**

*Kenneth A. Small, Robert B. Noland, Pia Koskenoja*

Examines behavioral reactions to the impact of changes in the probability of a non-recurrent incident and how

this effects the expected costs of a commute trip. Assesses the impact of socioeconomic variables, with a detailed classification of occupational groupings.

UCB-ITS-PRR-95-36

November 1995, 115 pp, \$20.00

**Summary of Observations on July 1993 Study Tour to Japan**

*Donald E. Orne, Steven E. Shladover*

The authors report on visits with academic institutions, government ministries, and automotive companies. Also an overview of the Intelligent Vehicle '93 Conference.

UCB-ITS-PWP-93-14

October 1993, 23 pp, \$5.00

**Transportation Opportunities and Constraints: The Performance of Urban Highway Transportation**

*William L. Garrison*

Considers system performance as such and the status of the economic and social services enabled by the system.

UCB-ITS-PWP-87-5

December 1987, 24 pp, \$5.00

**Using Technology to Improve Transportation Services**

*William L. Garrison*

The search for improvements is focused on marginal changes in service quality of decreases in costs. Electronics technology, for example, is being applied to smooth highway traffic, improve microwave aircraft landing systems, and tighten shippers' logistics systems.

UCB-ITS-PWP-88-7

May 1988, 32 pp, \$7.00



*Intellimotion*, PATH's quarterly newsletter, covers recent advances in PATH research for an audience with a general interest in intelligent transportation systems. Recent topics have been the why and how of roadway surveillance, automated highway systems, sensor research, and computer simulations of AHS.

*Intellimotion* is available online at <http://www.path.berkeley.edu.intellimotion>. For a free hardcopy subscription, please FAX, mail, or email us a request with the following information:

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## PATH DATABASE

The California PATH Database, the world's largest database on Intelligent Transportation Systems, is now accessible at <http://sunsite.berkeley.edu/PATH>. The Database, created in 1989 under the sponsorship of the California PATH Program, is maintained by UC Berkeley's Harmer E. Davis Transportation Library. In these past eight years, the Intelligent Transportation Systems (ITS) field has truly taken on worldwide presence, with the California PATH Program having a prominent role. During the same time, the PATH Database itself has grown into the world's largest bibliographic resource in the field. With over 11,000 records, it reflects a wide coverage of ITS information from North America, Europe, Japan and Australasia, and represents a major contribution to the California PATH Program and to the ITS initiative in the United States.

Based upon the vast holdings of the Library of the University of California's Institute of Transportation Studies, the PATH Database includes abstracts covering books, journal articles, conference papers, technical reports, dissertations and selected news articles. Papers from transportation and engineering society proceedings, journals and reports comprise the core of the Database. These include contributions from the Transportation Research Board, ITS America, the California PATH Program, the Institution of Electrical Engineers, IEEE, ISATA, SPIE and scores of other scholarly organizations. Documents received on worldwide information exchange agreements from international programs such as DRIVE, PROMETHEUS, and ERTICO, also form another core group of records.

Also available is the *Monthly PATH Recent Additions List*, a collection of 150-200 recent citations to the database is available at <http://www.lib.berkeley.edu/~path>. Detailed search instructions are provided on the Web site.

The following pages show a selection of entries from the PATH Database.



For further information, please contact:  
 Seyem Petrites at: [spetrite@library.berkeley.edu](mailto:spetrite@library.berkeley.edu)  
 Michael Kleiber at: [mkleiber@library.berkeley.edu](mailto:mkleiber@library.berkeley.edu)  
 Steve Morris at: [smorris@library.berkeley.edu](mailto:smorris@library.berkeley.edu)

Harmer E. Davis Transportation Library  
 Institute of Transportation Studies  
 412 McLaughlin Hall  
 Berkeley, CA 94720

**REFNO: 8049**

AU Adams, Lisa D.; Flannagan, Michael J.; Sivak, Michael  
 CORP University of Michigan, Transportation Research Institute  
 TI Obstacle avoidance maneuvers in an automobile simulator.  
 DT 1995.  
 PUB University of Michigan, Transportation Research Institute, Ann Arbor MI  
 REP RCE-939402; UMTRI-95-3  
 PG iii, 20 p..  
*KW Automobile driving; Driving simulators; Human factors.*

AB This study was conducted to determine the strategies subjects use to avoid an obstacle on the road with a limited preview distance at a relatively high speed, and to investigate whether these strategies are influenced by driver age and sex. The studies were conducted in a driving simulator.

**REFNO: 8051**

AU Kihl, Mary  
 TI Improving interbus transfer with automatic vehicle location.  
 DT 1995  
 CORP Midwest Transportation Center, Ames, Iowa  
 SP Iowa Dept. of Transportation; United States Dept. of Transportation  
 PG 57 p.  
*KW Automatic vehicle location; Public transit; Paratransit services; Global positioning system.*

AB This report presents an overview of automatic vehicle location (AVL) technology and its applications to public transit. It gives an assessment of the application to the Des Moines Metropolitan Transit Authority. A review of issues associated with application to a rural demand-responsive system is discussed. Finally, an assessment of components for an AVL application and a set of recommendations are presented.

**REFNO: 8077**

AU Hsu, Pau-Lo, Lin, Ken-Li, Shen, Li-Cheng  
 CORP Kuo li chiao tung ta hsueh. Institute of Control Engineering  
 ART Diagnosis of multiple sensor and actuator failures in automotive  
 SO IEEE transactions on vehicular technology. Vol. 44, no. 4  
 DT November 1995.  
 PG p. 779-789  
*KW In vehicle sensing systems; Fault monitoring*

AB This paper presents a diagnostic system which can effectively identify multiple sensor and actuator failures in engines systems. Simulation and experimental results indicate the proposed system not only can be applied to cases where all failures occur in the same sector, but is also appropriate for isolating multiple failures occurring simultaneously in sensors and actuators

**REFNO: 8079**

AU Lacey, Neil; Cameron, Max  
 ART Mayday in the Rockies : Colorado's GPS-based emergency vehicle location system.  
 SO GPS world. Vol. 6, no. 10  
 DT October 1995  
 PG p. 40-47  
*KW Automatic vehicle location; Global Positioning System; Motorist aid systems*

AB This article describes an GPS (Global Positioning System)-based emergency vehicle location system being developed through a public partnership in Colorado. The program, which is among the first of its kind in the U.S., has just passed its first milestone - prototype demonstration of the emergency vehicle location technology - and is proceeding toward full-scale testing and deployment in a test area in and around Denver.

**REFNO: 8083**

AU Hollis, B.J.  
 ART Telematics and information for the automobile user : the intelligent car  
 SO Smart vehicles  
 DT 1995  
 PUB Swets & Zeitlinger, Lisse, Netherlands  
 PG p. [37]-44.  
*KW Driver information systems; Telematics; ERTICO (Organization)*

AB This paper begins with a general discussion on the benefits of telematics. It then describes ERTICO, the European Road Transport Telematics Implementation Coordination Organization. It gives a brief description of the different sectors identified by ERTICO which form the system of road transport telematics. These include: traffic management, pre-trip management, on-trip management, vehicle control, freight and fleet management, and automatic fee collection.

**REFNO: 8109**

AU Sexton, G.  
CORP University of Northumbria at Newcastle  
ART Advances in automated pedestrian counting  
SO European Convention on Security and Detection (1995 : Brighton, England)  
DT 1995  
PUB Institute of Electrical Engineers, London  
PG p. 106-110  
*KW Image processing; Pedestrian detectors; Real time information*

AB This report focuses on the PEDMON (PEDestrian MONitoring) project which studies the development of technologies for automated pedestrian counting. The report describes the video image processing work, hardware and network development associated with the project. In the first section, aspects of the image processing algorithms are discussed. In the second section, the hardware and network developed for the intelligent sensors are detailed. In the third section, the system performance is discussed based on real data taken from the installation at the St. Lazare Railway Station in Paris.

**REFNO: 8111**

AU Grabow, P.C.; Liu, L.  
CORP Daylor University, Dep. of Computer Science  
ART Automatic generation of C++ code from an ESCRO2 specification  
SO International Computer Software and Applications Conference (19th : 1995 : Dallas, Tex.). Proceedings. COMPSAC '95  
DT 1995  
PUB IEEE Computer Society Press, Los Alamitos CA  
PG p. 18-24  
*KW Real time control; Traffic signals; Traffic control*

AB ESCRO2 is a specification language for real time systems. This paper describes the capabilities of the ESCRO2 processor to generate C++ code from an ESCRO2 specification. A traffic light control system is used to illustrate the concepts.

**REFNO: 8113**

AU Arnold, James A.  
CORP United States, Federal Highway Administration  
ART Navigating the future  
SO Public roads. Vol. 59, no. 2  
DT Autumn 1995  
PG p. 4-10  
*KW Global Positioning System; Intelligent transportation systems*

AB This article explains how electronic and other high-tech "gadgets" are being used to enhance efficient transportation and emphasizes how the transportation uses of technologies originally developed for national defense. The article focuses on GPS (Global Positioning System) and SPS (Standard Positioning System) and covers the areas of errors, user needs and requirements, augmented SPS (Standard Positioning Service) , and possible future developments.

**REFNO: 8130**

AU Chatzioanou, Alypios  
CORP California Polytechnic State University, San Luis Obispo  
ART Video image processing systems : applications in transportation  
SO Vehicle Navigation and Information Systems Conference (6th : 1995 : Seattle, Wash.). 1995 Vehicle Navigation & Information Systems Conference proceedings  
DT 1995  
PUB IEEE Service Center, Piscataway NJ  
PG p. 17-20  
*KW Traffic surveillance; Image processing*

AB This paper reports on a two phased study which assessed the potential of using video image processing (VIP) systems for traffic surveillance and detection on California freeways. Under phase one, eight turn-key and prototype systems were identified and tested under laboratory conditions. In phase two, four VIP systems were chosen for extended field testing to measure various factors. This paper presents the Phase II field test results and recommendations for standardizing image processing systems with a view toward eventual statewide implementation for traffic detection.



**REFNO: 8133**

AU Chang, Amoeba T.S.  
 CORP Tan-chiang ta hsueh  
 ART Adaptive signal control expert by artificial neural network training  
 SO Vehicle Navigation and Information Systems Conference (6th : 1995 : Seattle, Wash.).  
 1995 Vehicle Navigation & Information Systems Conference proceedings  
 DT 1995  
 PUB IEEE Service Center, Piscataway NJ,  
 PG p. 35-39  
*KW Advanced traffic management systems; Adaptive control systems; Neural networks; Traffic signals.*

AB This paper describes an advanced signal system (INTELS) with the subsystem Intelligent Traffic Signal control Software (ITSS). Focus is on determining signal phases and timing. Expert systems and an artificial neural network model are used in dealing with the range of control requirements.

**REFNO: 8147**

AU Schrijver, Peter Ronald  
 CORP Technische Universiteit Delft  
 TI Supporting fleet management by mobile communications  
 DT 1993  
 PUB National Technical Information Service, Springfield VA  
 PG 240 p  
*KW Trucking; Commercial vehicle operations; Mobile communication*

AB This dissertation investigates the possibilities mobile communications have to support the daily tasks of road haulage dispatchers. It focuses on the development of an information system that incorporates mobile communication technology and on establishing the benefits of using such an information system.

**REFNO: 8150**

AU Campbell, Darwin; Bradshaw, Catherine  
 TI Riderlink : transportation options on the Internet  
 DT 1995  
 PUB American Public Transit Association, Washington DC  
 PG 10, [2] p  
*KW Public transit; Advanced traveler information systems; Computer networks*

AB This paper describes Riderlink, a World Wide Web site on the Internet which provides electronic information about transportation options in the Seattle/Puget Sound Region. The focus of the project is to provide, via home and office PCs and kiosks, a broad range of transportation options information.

**REFNO: 8155**

AU Sandler, Larry  
 ART Big bus driver is watching : new system tracks routes, riders  
 SO Milwaukee Journal Sentinel  
 DT July 19, 1995  
 PG p. B7.  
*KW Automatic vehicle location; Buses; Satellite telecommunication.*

AB This article describes the Milwaukee County Transit System's use of satellites to track the location of buses in their fleet. This \$7.9 million Smart-Track communications and vehicle-locator also indicates to transit system dispatchers which bus is on schedule, has taken a wrong turn or needs help from security officers or maintenance workers

**REFNO: 8158**

AU Catchpole, John; Hancock, Adrian; Cairney, Peter  
 CORP ARRB Transport Research Ltd.  
 TI Driver comprehension of formats for presenting traffic information on dynamic signs  
 DT 1995  
 SER Research report ARR; 269  
 PUB ARRB Transport Research Ltd., Vermont South, Vic.  
 PG 106 p  
*KW Variable message signs; Traffic signs; Driver information systems*

AB This report describes the Drive Time system which was begun in July 1995 on Melbourne's South Eastern Arterial to provide drivers with information about traffic conditions and incidents on the arterial. Before installation of the Drive Time system, driver comprehension of various possible formats for the Trip Information Signs was investigated. Formats investigated included

vehicle speeds, travel times and descriptive labels. Color coding of the signs was also studied to see if it would result in improved comprehension of the information presented.

**REFNO: 8171**

AU Hickman, Mark D.; Wilson, Nigel H.M.

ART Passenger travel time and path choice implications of real-time transit information  
SO Transportation research. Part C, Emerging technologies. Vol. 3C, no. 4 (Aug. 1995)  
SP University Transportation Centers Program (U.S.); Massachusetts Bay Transportation Authority

PG p. 211-226

*KW Travel behavior; Travel time; Advanced traveler information systems; Public transit*

AB This paper considers information systems in public transit in which the passenger receives information in real time regarding projected vehicle travel times. To provide a preliminary assessment of these systems, an analytic framework is presented to evaluate path choices and travel time benefits resulting from real-time information. A behavioral model of transit path choice is presented that frames the choice in terms of a decision whether to board a departing vehicle. This path choice model accommodates network travel times that are both stochastic and time-dependent. The path choice model is extended to demonstrate how real-time information may be incorporated by the passenger in making a path choice decision. This analytic framework is applied to a case study corridor at the Massachusetts Bay Transportation Authority, using a computer simulation to model vehicle movements and passenger path choices in the corridor.

**NO 8520**

AU Kiselewich, Stephen J.; Turner, Douglas D.

CORP Delco Electronics Corporation

ART Using a neural network to distinguish between deployment events and non-deployment events in a supplemental inflatable restraint system

SO Automotive electronics; a review of technical achievements at Delco Electronics

DT 1995

PG p. 5-10

*KW neural networks; traffic accidents; vehicle technology*

AB This article describes an advanced supplemental inflatable restraint (SIR) controller which uses a three-layer, fully interconnected, feedforward neural network to distinguish between deployment and nondeployment events.

**NO 8530**

AU Taylor, Steven T.

ART Losing Wait

SO ITS World, Vol. 1, no. 1

DT January/February 1996

PG p. 28-31

*KW weigh in motion; automatic vehicle identification; commercial vehicle operations; trucking; Advantage I-75 (Program)*

AB This article reviews the Advantage I-75 Program and describes how weight-in-motion, automatic vehicle identification (AVI) readers, and in-vehicle transponders are helping truckers speed past weigh stations without compromising safety.

**NO 8568**

AU Goolsby, Merrell E.; McCasland, William R.

CORP Texas Transportation Institute

TI Houston ITS priority corridor program plan

DT 1995

SER TTI research report; 2931-2

PUB Texas Transportation Institute, College Station, TX

SP Texas Dept. of Transportation, Office of Research and Technology Transfer

REP FHWA/TX-95/2931-2

PG 98 pg in various pagings

*KW Intelligent transportation systems; advanced traffic management systems; advanced traveler information systems*

AB This report documents development of the 20-year Houston Intelligent Transportation Systems (ITS) Priority Corridor Plan. It is structured in three implementation time frames; Short Range, Intermediate Range, and Long range. There are 37 individual deployment projects identified in the Plan. The Plan builds upon the existing and evolving ITS core infrastructure of the Corridor, ranging from technologies such as the freeway and HOV lane Computerized Transportation Management System, Electronic toll Collection System, Automatic Vehicle Identification, computerized traffic signals, motorist assistance program, METRO smart bus, and the Houston TranStar center.



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